GEORGIA INSTITUTE OF TECHNOLOGY | OFFICE OF CONTRACT ADMINISTRATION

# PROJECT ADMINISTRATION DATA SHEET

[x] ORIGINAL [ ] REVISION NO. ______

Project No. A-3133 DATE 1/7/82

Project Director: J. C. Butterworth ~~School~~/Lab RAIL/RED

Sponsor: Norden Systems, Norwalk, CT.

Type Agreement: Purchase Order No. 51-0033602-ES (TWX Authorization*)

Award Period: From 12/17/81 To ~~12/16/82~~ 12/17/83 (Performance) 5/30/82 (Reports)

Sponsor Amount: $96,582 Contracted through:

Cost Sharing: None GTRI/~~GIT~~

Title: TALONS Modulator/HVPS, a 95 GHz Airborne EIO Transmitter

## ADMINISTRATIVE DATA

OCA Contact William F. Brown x4820

1) Sponsor Technical Contact:

Mr. Kenneth Koester

2) Sponsor Admin/Contractual Matters:

Mr. J. R. Mihalo
Subcontract Administrator
Norden Systems
A subsidiary of United Technologies
Norden Place, Norwalk, CT 06856
(203) 852-5803

Defense Priority Rating: none

Security Classification: none

## RESTRICTIONS

See Attached ______ Supplemental Information Sheet for Additional Requirements.

Travel: Foreign travel must have prior approval — Contact OCA in each case. Domestic travel requires sponsor approval where total will exceed greater of $500 or 125% of approved proposal budget category.

Equipment: Title vests with none proposed or anticipated

## COMMENTS:

*sponsor to send definitive purchase order



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GEORGIA INSTITUTE OF TECHNOLOGY OFFICE OF CONTRACT ADMINISTRATION

5R379

## SPONSORED PROJECT TERMINATION SHEET

Date August 16, 1983

**Project Title:** TALONS Modulator/HVPS, a 95 GHz Airborne EIO Transmitter

**Project No:** A-3133

**Project Director:** J. C. Butterworth

**Sponsor:** Norden Systems, Norwalk, CT.

**Effective Termination Date:** 12/17/82

**Clearance of Accounting Charges:** 12/17/82

**Grant/Contract Closeout Actions Remaining:**

P.O. #51-0033602-ES
P.O. #51-0051773-ES

- [x] Final Invoice ~~and Closing Documents~~ (one Final Invoice for each P.O.)
- [ ] Final Fiscal Report
- [ ] Final Report of Inventions
- [ ] Govt. Property Inventory & Related Certificate
- [ ] Classified Material Certificate
- [ ] Other ____________

**Assigned to:** RAIL-IMD (~~School~~/Laboratory)

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A-3133

ENGINEERING EXPERIMENT STATION
Georgia Institute of Technology
A Unit of the University System of Georgia
Atlanta, Georgia 30332

19 February 1982

Norden Systems
Mr. J. R. Mihaly
Subcontracts Administrator
Norden Place
Norwalk, Connecticut 06856

Attention : Mr. J. R. Mihaly, Mr. Kenneth Koester

Subject : Monthly Progress Report Number 1 under Project A-3133 on Purchase Order No. 51-0033602-ES Covering the Period 17 December 1981 to 31 January 1982

Gentlemen:

This monthly progress letter summarizes the activities on the above reference purchase order are summarized below.

Program Status

The program startup and organization was severely handicapped by the inadvertent delay in the program award date. During the delay key engineering personnel were reassigned to existing contracts. Every effort will be made to reduce the anticipated sixty day delay as much as possible. Mr. Jerry Goldbaugh of our Office of Contracts Administration will be in contact with you with the details.

Electronic Development

The electronic design and development tasks for the Modulator, High Voltage Power Supply (M-HV/PS) are in progress. A good percentage of the parts necessary have been ordered with appropriate substitutes being considered for extremely long lead items. The high voltage power supply multiplier chain has been breadboarded and successfully operated in an oil bath. The final circuits will be encapsulated in silicon jell.

Two modulator circuits will be investigated. One will consist of two ceramic planar triodes in a floating push pull circuit. The Eimac triodes for the circuit have been ordered and are scheduled for delivery at the end of February. The alternate modulator circuit will use a string of six or seven V FET's per side in a push pull arrangement. Preliminary tests using the two FET's in series protected by zener diodes and a vacuum spark gap have withstood several hundred 0.2 Joule arcs from a 12 kV power source without failure. Protecting a solid state modulator from an EIO or power supply arc is a major problem that must be overcome in order to successfully design an all solid state M-HV/PS.

Mechanical Design

A model of the high voltage power supply unit has been fabricated but not assembled. Connector sizes and types are being discussed with John Carullis and will be incorporated in this model. Discussion of the high voltage flexible cable and connectors is in progress. The breadboard model power supply assembly will accommodate up to 15 4" x 5" x .09 printed circuit boards on half inch spacings. Approximately one third of this space will be occupied by the 21 kV power supply and will be encapsulated. This package size does not exceed the required dimensions.

Financial Status

The expenditures and encumberances for December and January are $10,160 for materials, personal services, and overhead.

Respectfully submitted,

[redacted]
J. Clark Butterworth
Project Director

Approved:

[redacted]
N. C. Currie, Chief
Radar Experimental Division

A - 3133

ENGINEERING EXPERIMENT STATION
Georgia Institute of Technology
A Unit of the University System of Georgia
Atlanta, Georgia 30332

19 March 1982

Norden Systems
Mr. J. R. Mihaly
Subcontracts Administrator
Norwalk, Connecticut 06856

Attention : Mr. J. R. Mihaly, Mr. Kenneth Koester

Subject : Monthly Progress Report Number 2 on Purchase Order No. 51-0033602-ES (GIT Project A-3133) Covering the Period 1 February 1982 to 28 February 1982

Gentlemen:

This progress letter summarizes the activities on the subject purchase order during the referenced period.

Program Status

The program now has completed its tenth week and now has its staffing to approximately eighty percent level with expenditure below the anticipated rate. Technical progress is advancing smoothly with no further delays in sight.

Electronic Development

The three phase 400 Hz-to-DC rectifier and filter circuit board has been designed, and layout is in progress. The 100 kHz DC to 22 kV converter circuit board has been designed, and the circuit is being manufactured at this time.

A breadboard solid state 3 kV pulser has operated successfully over pulse widths from 50 ns to 1 $\mu$s using series FET's, although further development will be required to complete the driver circuitry.

## Mechanical Design

The high voltage power supply unit is not completely assembled and is awaiting power and signal connector specifications from Norden. The high voltage, high flexibility cable and connectors to be provided by Norden are also needed at this time.

## Financial Status

The expenditures and encumberances on the Purchase Order for February total \$14,346. The expenditures to date for materials, personal services, and overhead are thus \$24,506.

Respectfully submitted,

[redacted]

J. Clark Butterworth
Project Director

Approved:

[redacted]

N. C. Currie, Chief
Radar Experimental Division

ENGINEERING EXPERIMENT STATION
Georgia Institute of Technology
A Unit of the University System of Georgia
Atlanta, Georgia 30332

20 April 1982

Norden Systems
Mr. J. R. Mihaly
Subcontracts Administorator
Norwalk, Connecticut 06856

Attention : Mr. J. R. Mihaly, Mr. Kenneth Koester

Subject : Monthly Progress Report Number 3 on Purchase Order No. 51-0033602-ES on Project A-3133 Covering the Period 1 March 1982 to 31 March 1982

Gentlemen:

This progress letter summarizes the activities on the subject purchase order during the referenced period.

**Program Status**

The program has completed its fifteenth week and currently delivery difficulties are being encountered with key components associated with the high voltage power supply. Due to these delays delivery before the 30 June 1982 date anticipated in progress letter No. 1, dated 19 February 1982, now seems impossible. A formal request for a no cost extension was submitted to Norden last month and pending other instructions, the 30 June 1982 delivery date is being assumed by Georgia Tech.

**Electronic Development**

The three phase rectifier circuit board and the 22 kV converter circuit boards are being delayed because of late delivery of several components. Some temporary substitutes have been made to begin testing ofthe circuits. However the circuits cannot be fully tested until the third week of April assuming the promised delivery schedules are met.

Testing of the planar triodes heat sink mounting design is now in progress. If stray mounting capacitance, and thermal build up do exceed the calculated values, a test modulator output stage will then be assembled.Monthly Progress Report Number 3
Purchase Order 51-0033602-ES

The testing of the over and under voltage protector circuit has been hampered by the delay in delivery of an integrated circuit. An alternate source has been located and orders have been placed.

## Mechanical Design

The high voltage cable and connectors are due to arrive from Norden Systems during April. This should complete the high voltage power supply to modulator interface. High voltage insulating and heat conducting jells are being tested for reliability and mechanical strength. The more fluid jells seem to encapsulate and penetrate better yielding more protection from corona breakdown but they give little or no mechanical support to high voltage components or wires. No decision has been made yet as to final selection of the encapsulation material.

## Financial Status

The expenditures and encumberances for March are $14,394 for a total of $35,046 to date.

Respectfully submitted,

[redacted]

J. C. Butterworth
Project Director

JCB:jct

Approved:

[redacted]

N. C. Currie, Chief
Radar Experimental Division

ENGINEERING EXPERIMENT STATION
Georgia Institute of Technology
A Unit of the University System of Georgia
Atlanta, Georgia 30332

9 June 1982

Norden Systems
Mr. J. R. Mihaly
Subcontracts Administrator
Norden Place
Norwalk, CT 06856

Attention: Mr. J. R. Mihaly
Mr. Kenneth Koester

Subject: Monthly Progress Report Numbers 4 & 5 on Purchase Order No. 51-0033602-ES Covering the period 1 April to 31 May 1982.

Gentlemen:

This progress letter summarizes the activities on the subject purchase order during the referenced period.

Program Status

The Modulator power supply development program is experiencing unanticipated difficulties in the 22 kv converter circuits. Component failure is being experienced with seemingly no explanation. The switching FET's fail despite derating and external protective circuits.

A program review meeting is scheduled for 10 June with two Norden Systems representatives coming to Georgia Tech. Mechanical configuration of the on-axis Modulator, as well as overall system signals will be decided at this meeting. A new "Schedule to Completion" will also be discussed.

Electronic Development

The decision has been made to use the vacuum tube model for the Modulator for two reasons. (1) The successful test potting of a Eimac 8847A planar triode and the measurement of an acceptable stray capacity involved with the potting process, and (2) the requirement for twelve FETs to be used in the solid state model along with the unpredicability of a spark gap to high frequency short pulses.

Mechanical Design

Final agreement should be made about the mounting method and electrical connections at the design meeting to follow on the 10th of June. Engineering sketches will be exchanged throughout this decision period as needed.

Financial Status

The expenditures and encumberances for April were $14,286 for a total of $49,332 and for May were $18,475 for a total of $67,807. This represents the 70% point in funds expenditure. We are currently evaluating our program and a schedule for completion will be determined at our 10 June meeting.

Respectfully submitted,

[redacted]

J. C. Butterworth
Project Director

Approved:

[redacted]

N. C. Currie, Chief
Instrumentation and Measurements Division
Radar & Instrumentation Laboratory

JCB:mh

ENGINEERING EXPERIMENT STATION
Georgia Institute of Technology
A Unit of the University System of Georgia
Atlanta, Georgia 30332

20 July 1982

Norden Systems
Mr. J. R. Mihaly
Subcontracts Administrator
Norden Place
Norwalk, CT 06856

Attention: Mr. J. R. Mihaly
Mr. Kenneeth Koester

Subject: Monthly Progress Report Number 6 on Purchase Order No. 51-0033602-ES Covering the Period 1 June through 30 June 1982.

Gentlemen:

This progress letter summarizes the activities on the subject purchase order during the referenced period.

Program Status

The program is now operating under a revised schedule to complete assembly in July and test during early August as discussed with Mr. J. M. Carulli and Mr. J. T. Cronan at a technical review conducted at Georgia Tech on 10 June 1982. All high voltage sections which will be jell impregnated must first undergo test and evaluation in an oil bath.

Electronic Development

The 22 kv beam power supply and frequency agility circuit have been evaluated in oil and final circuit modifications made. This 22 kv supply required considerably more effort to accomplish satisfactory operation because of the unusually high (60 KHz) operating frequency and the vulnerability to transient failure of the MOS/FET switching devices. The MOS/FET switches should prove to be superior to bipolars because of their high speed capabilities and low power dissipation.

A breadboard pulser has been assembled and tested with the capability of modulating the EIO as outlined in the design goals. The pulser consists of two EIMAC 8847A planar triodes operating in a floating deck grounded grid push-pull circuit. This switch is driven by an all solid state FET circuit. The high voltage interface between input and floating deck switch pulser is accomplished with a current transformer producing good pulse fidelity.

## Mechanical Design

Final approval of the mechanical design for the power supply and on-axis Modulator is now in progress with Mr. Carulli and Mr. Cronan. All interface and power connectors are on hand and ready for final installation. A set of test cables (one each high voltage, one each control) which are normally a part of the antenna assembly, will be required for system test during July. These cables will be returned with the completed transmitter to be used for testing when the gimbal harness is not accessible.

## Financial Status

The estimated expenditures for June are $18,275 for a total of $86,082. The remaining $9,780 will not be sufficient to complete and test the Modulator Power Supply. It is estimated that an additional $9,969 will be required, bringing the estimated total cost to complete to $106,551.

Respectfully submitted,

[redacted]

J. C. Butterworth
Project Director

Approved:

[redacted]

Charles E. Brown, Chief
Development Division
Radar & Instrumentation Laboratory

JCB:mh

ENGINEERING EXPERIMENT STATION
Georgia Institute of Technology
A Unit of the University System of Georgia
Atlanta, Georgia 30332

17 August 1982

Norden Systems
Subcontracts Administrator
Norden Place
Norwalk, CT 06856

Attention: Mr. J. R. Mihaly
Mr. Kenneth Koester

Subject: Monthly Progress Report No. 7 on Purchase Order 51-0033602-ES
Covering the period 1 July to 31 July, 1982.

Gentlemen:

This Progress Letter summarizes the activities on the subject purchase order during the referenced period.

Program Status

All circuit boards for the high voltage power supply unit have been completed and tested individually. The unit will be completed and ready for testing during the first week of August.

With the successful testing of a breadboard modulator, final circuit boards have been completed with assembly and 3kv testing scheduled within the first week in August.

Additional funding, as estimated in Progress Report No. 6, was requested on 26 July, 1982 as Proposal No. RI-DD-1303. Those funds will be necessary to complete the Modulator/HVPS.

EIO Evaluation

An evaluation of EIO No. E0304D2 was performed with a modulator at Georgia Tech to determine the expected frequency agility characteristics. Tests were conducted at three frequencies within the EIO's mechanical tuning range with voltage pushing factors of 74.7 MHz/kv at 96 GHz; 66.0 MHZ/kv at 95 GHz; and 49.3 MHz/kv at 94 GHz. Considering the low pushing factor for this EIO compared to estimated 150 MHz/kv from available Varian data, some redesign of the frequency agility circuitry and capability has been incorporated. The results of these changes will be evaluated when the completed power supply is tested on a resistive load, equivalent to normal long and short pulse operation.

Monthly Progress Report No. 7
Norden Systems

Mechanical Design

Final mechanical design changes of the on-axis unit were received from Duncan Bromley by telephone and a memo dated 7/29/82. These changes will all be incorporated within a week's time as the modulator circuit is installed within the unit.

Financial Status

The expenditures and encumberances for July were $11,900, for a total of $102,700. The expenditures for June were $23,000, not the estimated $18,275 as reported in Progress Report No. 6. The Modulator/HVPS will be completed for the total $106,551 as outlined on our Proposal No. RI-DD-1303.

Respectfully submitted,

[redacted]

J. C. Butterworth
Project Director

Approved:

[redacted]

C. E. Brown
Chief
Development Division
Radar and Instrumentation
Laboratory

JCB:mh

GIT/EES Project A-3133
Purchase Order No. 51-0033602-ES

Final Report
and
Operations Manual

# TALONS Modulator/High Voltage Power Supply
# A 95 GHz Airborne EIO Transmitter

by

J. C. Butterworth, G. M. Conrad, P. Fenoglio

Prepared for

United Technologies
Norden Systems
Norwalk, Connecticut 06856

by

Georgia Institute of Technology
Engineering Experiment Station
Atlanta, Georgia 30332

October 1982

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## SECTION 1
## GENERAL INFORMATION

WARNING

THIS EQUIPMENT EMPLOYS VOLTAGES THAT ARE EXTREMELY DANGEROUS AND MAY BE FATAL.

### 1.1 OVERVIEW

The TALONS Modulator/High Voltage Power Supply was developed for Norden Systems of Norwalk, Connecticut to operate a 95 GHz Extended Interaction Oscillator (EIO) transmitter and to be part of an airborne radar system. The transmitter is contained in two units (see Figure 1). A modulator unit which contains the EIO is mounted on the rear of a scanning antenna and must move on the axis of the antenna; this unit is sometimes referred to as the "on axis" unit. A high voltage power supply unit (HVPS) is connected to the modulator unit via appropriate cables through a cable wrap within the antenna elevation and azimuth axis and is referred to as the "off axis" unit.

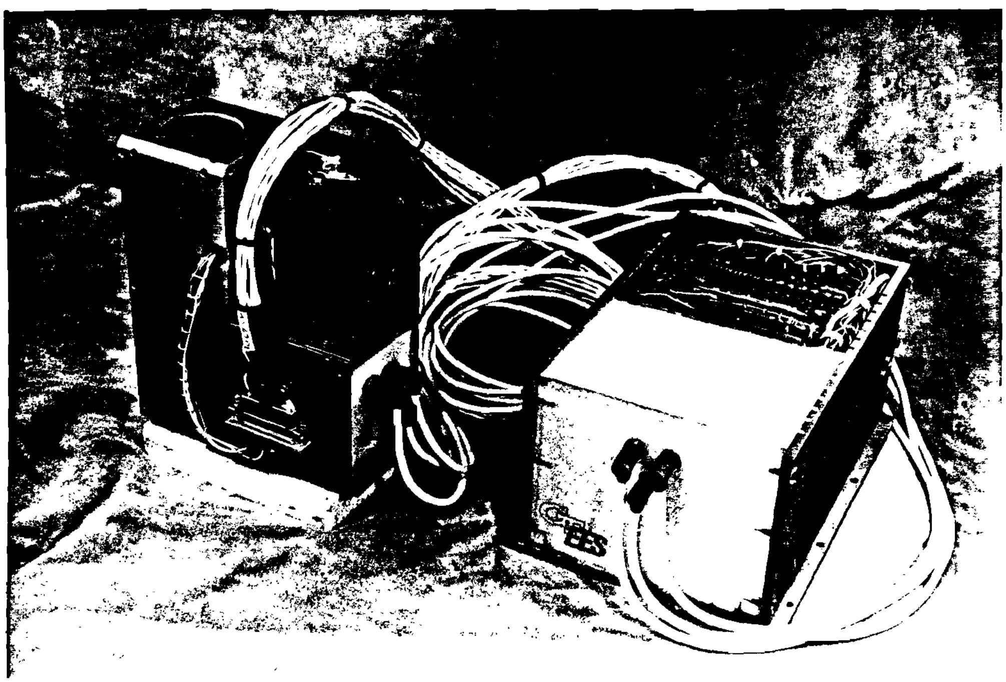



Figure 1. Transmitter Modulator/HVPS.

## 1.2 SCOPE OF MANUAL

This manual describes the operating and adjustment procedures for proper operation of the 95 GHz EIO transmitter. The transmitter operates at either of two fixed pulse widths at a constant pulse rate. A frequency agility mode is also available and is selectable via TTL command, as are pulse widths. Section 2 describes installation procedures and precautions. Section 3 contains operating instructions and features. Sections 4 and 5 contain operating principles and adjustment procedures. Section 6 discusses transmitter characteristics. The appendices include photographs of individual circuit boards showing component locations, the test plan, and schematic diagrams of the Modulator/HVPS.

## 1.3 TRANSMITTER DESCRIPTION

The transmitter consists of two units, a modulator unit and a high voltage power supply unit connected by a low voltage cable and three high voltage wires. The modulator contains the Extended Interaction Oscillator, a push-pull floating deck grid modulator with associated driver, and high voltage interface circuits. Power is supplied to the modulator circuits by dc-to-dc converters which isolate the necessary 21 kVdc EIO beam operating voltage. All high voltage (21 kVdc) circuits have been encapsulated in a thermally conducting silicone potting compound for protection against corona and high voltage breakdown.

The HVPS contains the 21 kVdc beam voltage supply, the 3 kVdc bias-modulator power supply, the focus offset voltage supply, and control and safety circuits, as well as interface circuits to the radar control. The HVPS is divided into two sections, each containing printed circuit cards which mount all individual components. One section, as in the modulator, is encapsulated with silicone compound to protect the high voltage area. Access to all adjustments, except mechanical tuning of the EIO, is gained by removing the cover from the HVPS. During normal operation, no adjustments should be required.

## 1.4 SYSTEM SPECIFICATIONS

The transmitter system was developed to meet the design goals given in Table 1.

TABLE 1. MODULATOR PARAMETERS

| PARAMETER | VALUE | |
|---|---|---|
| | Long Pulse | Short Pulse |
| RF Pulse Width 50% | 400 ± 40 ns | 80 ± 8 ns |
| Rise, Fall Time 10-90% | 10 ns | 10 ns |
| Pulse Delay | < 100 ns | < 100 ns |
| Pulse Jitter | 2 ns RMS | 2 ns RMS |
| Spectrum 1st Sidelobe | -10 dB | -10 dB |
| Amplitude Regulation<br>Pulse-to-Pulse | ± 1% | ± 1% |
| Frequency Variation<br>Pulse-to-Pulse<br>(Dependent on EIO Voltage<br>Pushing Factor) | 25 Vdc P-to-P Ripple | 25 Vdc P-to-P Ripple |
| Stability (f) Long-term | 1 MHz + Temp (EIO) | 1 MHz + Temp (EIO) |
| PRF | Var 6250 - 7500 | Var 6250 - 7500 |
| Duty | .0025 - .0003 | .0005 - .0006 |
| Max Peak Power | (EIO) | (EIO) |
| Max Avg Power | Peak x Duty | Peak x Duty |
| Frequency Agility Rate | 60 Hz | 60 Hz |
| FA Dispersion | 1.5 kVdc or 100 MHz | 1.5 kVdc or 100 MHz |
| FA Power Variation | 3 dB | 3 dB |

# SECTION 2
# INSTALLATION

## 2.1 SHIPPING

The Modulator/HVPS was constructed with overall ruggedness and air worthiness as a chief concern; however, care should be taken to properly protect the EIO and waveguide output flange. Any particle entering the waveguide could cause serious damage or loss of the waveguide window. Do not package magnetic material within 3 inches of the EIO.

## 2.2 MOUNTING

The Modulator mounting is accomplished by inserting the two tapered guide pins into the transmitter cavity on the antenna. Then secure the modulator with two 10 - 32 studs which attach to appropriate brackets. The modulator size, shape and mounting configuration conform to drawings furnished to Georgia Tech. The HVPS is secured within the flight pad by a series of screws which hold the bottom of the unit to a cold plate. If operation is anticipated without a cold plate heat sink, a fan with 80 to 100 cubic feet/minute of air flow should be directed on the unit.

## 2.3 OPERATING VOLTAGE

The unit is designed to operate from 3-phase, 200 Vdc, 400 Hz ac, $\pm$ 15 Vdc, $\pm$ 5 Vdc, and $\pm$ 28 Vdc connected as per Norden drawing No. 1339-00440. In addition, a 240 Vdc auxiliary, highly regulated power supply may be used as a source voltage for the 22 kVdc beam voltage with some gain in overall stability. The substitution of this auxiliary power supply will be discussed in Section 5.2, Beam Voltage Adjustment Procedure.

## 2.4 TEMPERATURE

The transmitter has been designed with flight temperature ranges as a goal; however, only laboratory operation has been performed.

## 2.5 HIGH VOLTAGE CABLE

The high voltage cable required for operation through the antenna axis twist package requires special consideration for safety and proper operation. FATAL VOLTAGES appear on this cable and the contacts are secured only by friction. It is recommended that additional security be added in the form of plastic cover/security panels at both ends of this cable. Great care must be taken to properly connect the three wires. A reversal of any of the three high voltage wires will result in serious damage to the transmitter unit.

## SECTION 3
## OPERATING INSTRUCTIONS

### 3.1 PRECAUTIONS

WARNING

THIS EQUIPMENT EMPLOYS VOLTAGES THAT ARE EXTREMELY DANGEROUS AND MAY BE FATAL.

After all cables have been installed and appropriate waveguides are in place, power may be applied to the unit with controls in the OFF position. The cooling fan for the EIO should then be checked for rotational direction. Air should be flowing out across the collector fins. If not, remove the top fan mounting plate and reverse any two wires connected to the fan.

### 3.2 TURN-ON PROCEDURE

Place remote panel transmitter switch in STANDBY and confirm HEATER DELAY light operation. After approximately two minutes, the HEATER DELAY light will go OFF, indicating that the transmitter is in STANDBY. The transmitter can now be switched from STANDBY to RADIATE and back, with no further delay. If so desired, RADIATE can be selected directly from OFF with the remote panel transmitter switch. The transmitter will then be automatically switched to RADIATE after the two minute time delay.

### 3.3 OPERATING FEATURES

#### 3.3.1 REMOTE CONTROLS

All functions are controlled from a remote control panel. The transmitter unit will not function unless connected to the proper interface controls and signals. All connections are as illustrated in Norden drawing No. 1329-00440.

### 3.3.2 MODE OPTIONS

The transmitter can be operated in long (400 ns) or short (90 ns) pulse width mode on command. The beam voltage can be varied at a 60 Hz sinusoidal rate to produce electronic tuning of the EIO. The electronic tuning command voltage amplitude and the offset is supplied via the cable from the IF unit of the radar. Frequency agility can be applied during long or short pulse operation.

### 3.3.3 AUTOMATIC PROTECTION

In the event of a malfunction of the Modulator/HVPS, fault protection circuits have been provided to automatically cycle the transmitter to the STANDBY condition. If a fault occurs, the FAULT light will energize at the remote control panel. If the FAULT is temporary and no damage has occurred, the RESET switch may be operated and normal operation resumed. If the FAULT remains, corrective action must be taken. Section 4.5, Protective Circuits, describes the protective features monitored by the Fault Protection Circuitry.

# SECTION 4
# PRINCIPLES OF OPERATION

## 4.1 GENERAL

The TALONS transmitter consists of a Varian VKB2443 Extended Interaction Oscillator with the power supplies and pulse amplifier circuits required to produce the desired millimeter wave pulse used in the radar system.

Although a detailed description of circuit operations is beyond the scope of this operator's manual, some understanding of the circuit operation and location of individual components may be gained by referring to Appendix C where interconnecting diagrams and individual printed circuit schematic diagrams will be found. Appendix A contains front and rear side photos of each circuit card within the Modulator/HVPS.

## 4.2 CONTROL CIRCUITRY

The Modulator/HVPS is an integral part of the complete transmitter. All operator controls are found on the central radar control panel. All power is supplied through connector C from the main radar harness. Control functions are connected via connectors D and B. The control panel selector switch has three positions: OFF, STANDBY, and RADIATE. Panel lamps are used to indicate the status of the transmitter. Along with the STANDBY and RADIATE lamps, there are lamps indicating HEATER DELAY, a condition which exists for two minutes from OFF to STANDBY, and also a FAULT lamp which illuminates to indicate a malfunction or overload condition. The STANDBY and RADIATE lamps only indicate the position of the control panel selector switch. A FAULT/RESET switch is available to reset the FAULT circuitry when the condition has been corrected. If a FAULT occurs a second time upon RESET, further corrective action is required. An average EIO beam current meter is provided and should be monitored once proper operating parameters have been established. All control circuits are located on the Fault Protection Circuitry (T) card of the off-axis unit.

## 4.3 POWER SUPPLIES

Three dc voltages are required to operate the EIO and Modulator. The 22 kVdc supply is located within the off-axis unit on three circuit cards: the Power Board (P), Multiplier (M), and 22 kVdc Regulator (R). The 22 kVdc supply converts the 3-phase, 400 Hz ac to 140 Vdc with rectifiers and a switch-mode regulator. The 140 Vdc is applied to an inverter and a times twelve multiplier to produce the required 22 kVdc for the cathode (beam) voltage of the EIO. The second supply produces the 3 kVdc bias and modulator operating voltage. The third supply provides 142 Vdc to properly focus the EIO beam current. The last two power supplies are located on Regulator/Chopper Circuitry card (K) and BiasFocus Multipliers card (F). Both bias and focus supplies are dc-to-dc converter multipliers, operating from the 28 Vdc power input line. Three-terminal regulators supply the required adjustment for each of these two supplies.

## 4.4 MODULATOR

The Modulator consists of two basic types of circuitry. First, standard TTL digital logic devices are used to convert the modulator trigger timing pulse to the long or short pulse as necessary to produce the required RF output. This circuitry is contained on the Pulse Conditioning Driver card (D) in the off-axis unit. Second, additional digital and interface modules are used to create start and stop pulses which will produce the necessary signals to operate high voltage stages that "float" at the 22 kVdc beam potential. Low capacitance, high voltage transformers couple the start/stop pulses, the filament voltage, and the dc-to-dc converters from the ground referenced circuits to the beam referenced voltage, with all beam referenced circuitry being encapsulated in a silicone compound. The start/stop and filament drivers are located on the Pulse Circuitry/Filament Chopper Board in the on-axis unit. The start/stop pulses each operate a MOS FET amplifier which in turn operates a push/pull planar triode output amplifier to produce the necessary 3 kVdc modulator pulse. All of these modulator and driver components are located within the Hard Tube Switcher Circuitry assembly along with the EIO on the on-axis unit. Voltage offset of this high voltage pulse is adjusted with the focus power supply to ensure proper grid-to-cathode voltage of the EIO during the pulse.

## 4.5 PROTECTIVE CIRCUITS

The protective circuits located on the Fault Protection Circuitry (T) card within the off-axis unit act to protect the equipment and energize FAULT indicators if any of the following conditions exist:

| Fault Indicators | Condition |
|---|---|
| F1 | Not used |
| F2 | 22 kVdc HVPS over voltage |
| F3 | EIO beam over current |
| F4 | EIO body over current |
| F5 | Not used |
| F6 | 140 Vdc over voltage |
| F7 | 140 Vdc over current |
| F8 | EIO collector temperature |
| F9 | Not used |
| F10 | Not used |

The FAULT Protective Circuitry shuts down only the 22 kVdc power supply in order to protect the EIO.

Analysis of an indicated FAULT is aided with a set of light emitting diodes (LED) on card (T). Observing this latched indicator will give a clue as to the probable cause of failure. NOTE: These LEDs will remain latched-on unless the FAULT clears and the RESET switch is closed or the 5 Vdc power supply is de-energized.

## SECTION 5
## ADJUSTMENT PROCEDURE

### 5.1 PULSE WIDTH

The long and short pulses are selectable by remote control and their individual length is dependent on the pulse delay network tap wiring on card (D) and the characteristics of the EIO. Adjustments can be made in 10 ns steps on the short pulse and 20 ns steps on the long pulse.

### 5.2 BEAM VOLTAGE

**DANGER - HIGH VOLTAGE**

The beam voltage is controlled by the pulse width regulator on card (R). This voltage should be set according to the individual EIO's data sheet by the potentiometer (R40) on the (R) card in the HVPS. This voltage is lethal and must be measured with a high voltage probe at point Vk to ground on the off-axis unit.

As noted in Sections 2.3 and 4.3, normal operation of the beam supply is from 3-phase, 400 Hz ac voltage. Additional stability and harmonic ripple filtering can be achieved by using an auxiliary dc supply. This supply may be connected to the power input connector. However, the 3-phase ac must be disconnected from the Power Board (P) card and the 3-phase ac must be maintained for the cooling fan in the on-axis unit. To accomplish this, remove the off-axis cover and locate the three-wire shielded wire from input power connector to card (P). Locate the point labeled "CUT HERE". Cut and insulate all open ends and apply 240 Vdc to pins 21 and 20. This power may be applied along with all other prime voltages at system turn-on.

### 5.3 FREQUENCY AGILITY

An additional input has been provided to the beam voltage regulator into which a 60 Hz sine wave signal can be applied to generate beam voltage modulation. With the frequency agility (FA) input activated, approximately a one-volt peak-to-peak signal is supplied from the radar AFC unit. This signal should be capable of being offset from zero to approximately ± .5 Vdc to provide the proper adjustment of beam voltage. Frequency agility should only be adjusted with the detected RF pulse being observed on an oscilloscope. Care must be taken not to exceed normal tube beam voltage operating conditions with both the 60 Hz signal and the dc offset.

### 5.4 HEATER VOLTAGE

The heater voltage of the EIO is difficult to determine because of the silicone encapsulation. Proper operation of the EIO and push/pull modulator tubes exists when the filament chopper voltage on the collector of Q7 or Q8 in the Modulator measures 14.5 Vdc RMS on a true RMS voltmeter. Its adjustment is made by potentiometer R7 on card (K).

### 5.5 BIAS

DANGER - HIGH VOLTAGE.

The bias power supply is connected directly to the beam supply and must be measured with an isolated (floating) meter connected between $V_K$ and $V_B$ and should be 3 kVdc. Its adjustment can be made by potentiometer R3 on card (K).

### 5.6 FOCUS VOLTAGE

DANGER - HIGH VOLTAGE.

The focus power supply is connected directly to the beam supply and must be measured with an isolated (floating) meter connected between $V_K$ and $V_F$ and should be between 7 and 142 Vdc. Its adjustment can be made by potentiometer R9 on card (K).

SECTION 6
TRANSMITTER CHARACTERISTICS

## 6.1 TALONS TRANSMITTER TEST PLAN

The transmitter test plan was written by Norden as a means of documenting the performance of the Modulator/HVPS and EIO as a complete transmitter and evaluating its suitability to perform properly in the radar for which it was developed. The equipment was tested in accordance with the plan. This test plan, along with recorded data derived from the tests is contained in Appendix B.

## 6.2 INTERPRETATIONS AND RECOMMENDATIONS

Two distinctly different modes of operation of the transmitter are being implemented. One mode requires a highly stable, narrow, spectral bandwidth signal for long-range, high sensitivity. The other mode requires a frequency agile, broad, controlled spectral bandwidth for clutter reduction of non-critical target echoes. Unfortunately, a single millimeter wave oscillator design has been optimized to only one task. Varian Canada, the manufacturer of the VKB2443 EIO has delivered an oscillator with a smaller frequency pushing factor than had been anticipated on the tube design data sheet. Consequently, considerably less frequency agility can be achieved without appreciable loss of power. The spectrum photographs in Appendix B indicate test results. Good, narrow-band operation can be observed in test data taken when a well filtered and regulated auxiliary supply was used. Some broadening of the spectrum will occur when using a 400 Hz ac supply. The predominant problem with using the ac supply is the filter's inability to eliminate ripple caused by the 3-phase unbalance. With space being a limiting factor, additional filtering was not added. More stable, approaching coherent, operation might be accomplished through injection-locking methods used at lower frequencies and briefly experimented with on other programs at Georgia Tech. Good wideband operation may require the master oscillator power amplifier application as in chirp radars. With the development of a suitable wideband, high-gain driver, the millimeter Extended Interaction Amplifier (EIA) should fill the role of a high power output, wide bandwidth transmitter.

# APPENDIX A

## PHOTOGRAPHS OF CIRCUIT BOARDS

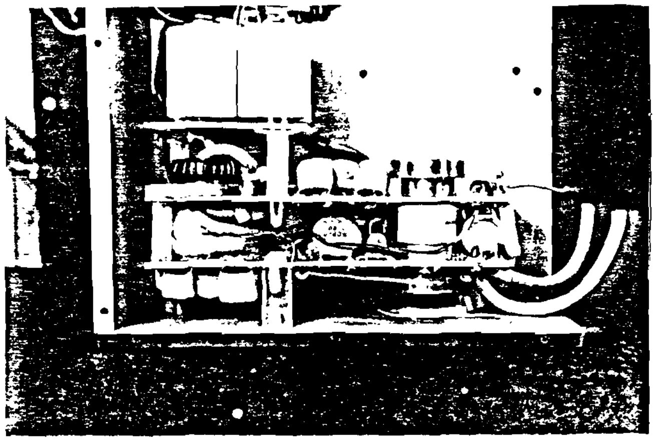


Figure A-1a. Hard Tube Switcher Circuitry ( assembled )

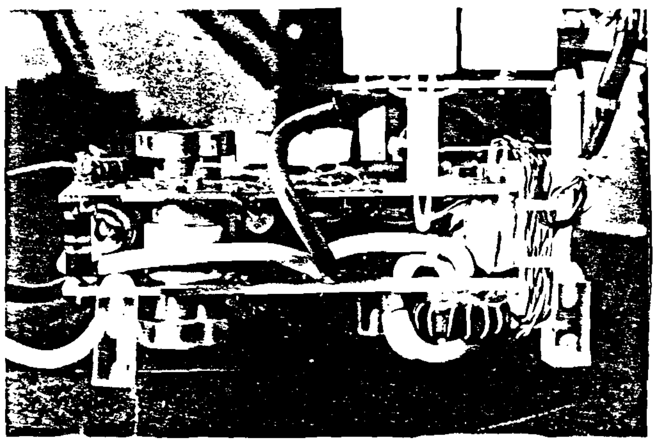


Figure A-1b. Hard Tube Switcher Circuitry (rear view )

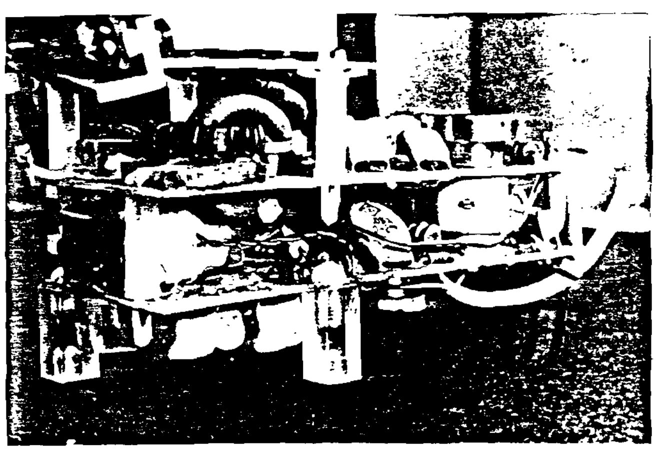


Figure A-1c. Hard Tube Switcher Circuitry ( front view )

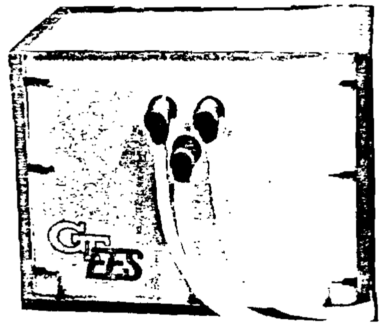


Figure A-2a. High Voltage Connector Off Axis Unit.

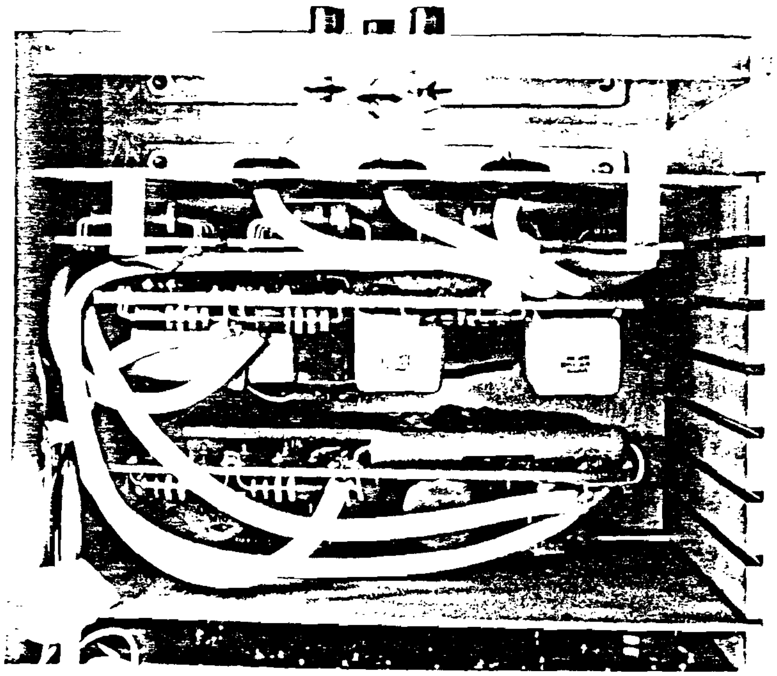


Figure A-2b. Top View of High Voltage Section, Off Axis Unit.

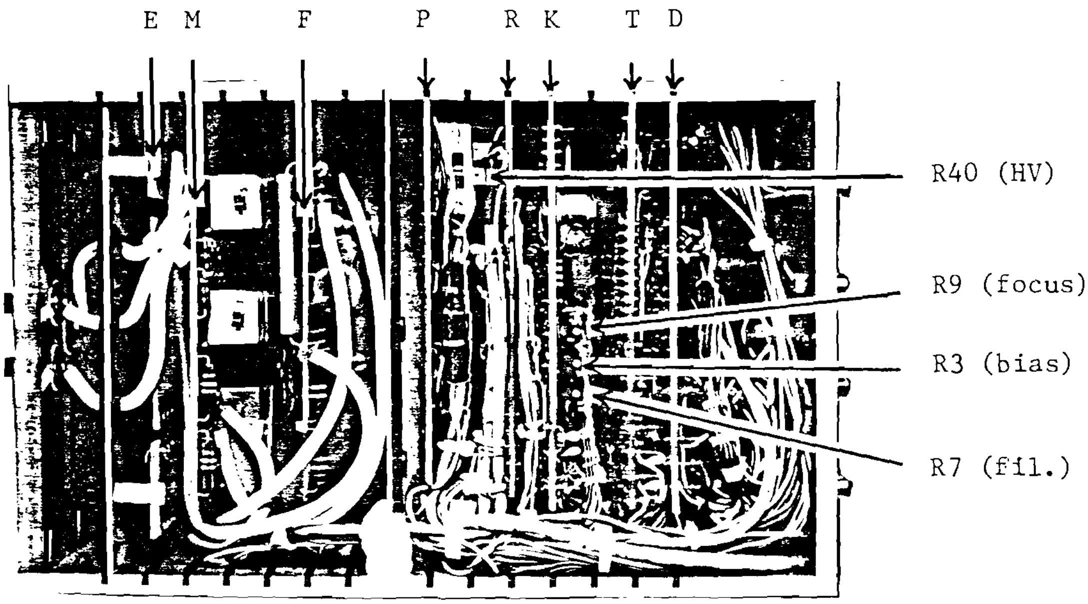



Figure A-3a. Top View of Off Axis Unit.

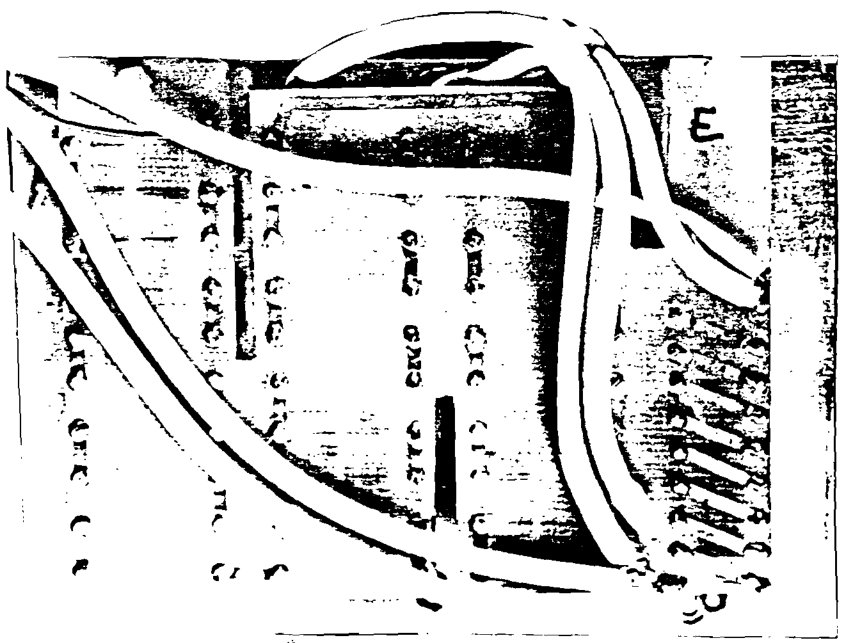



Figure A-3b. Rear View of Dummy Load Circuit Card. (E)

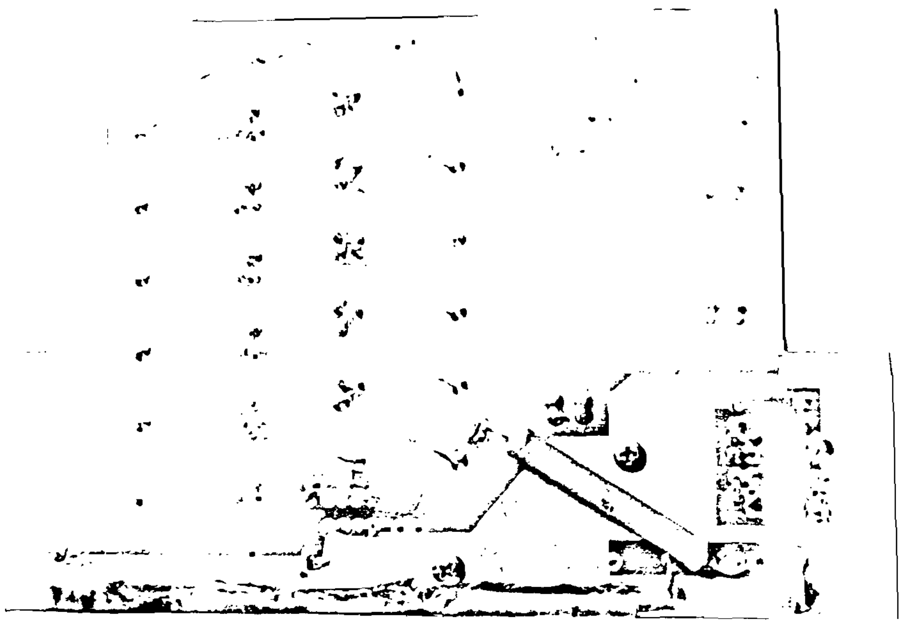


Figure A-4a. Rear View of X12 Multiplier Circuit card.(M)

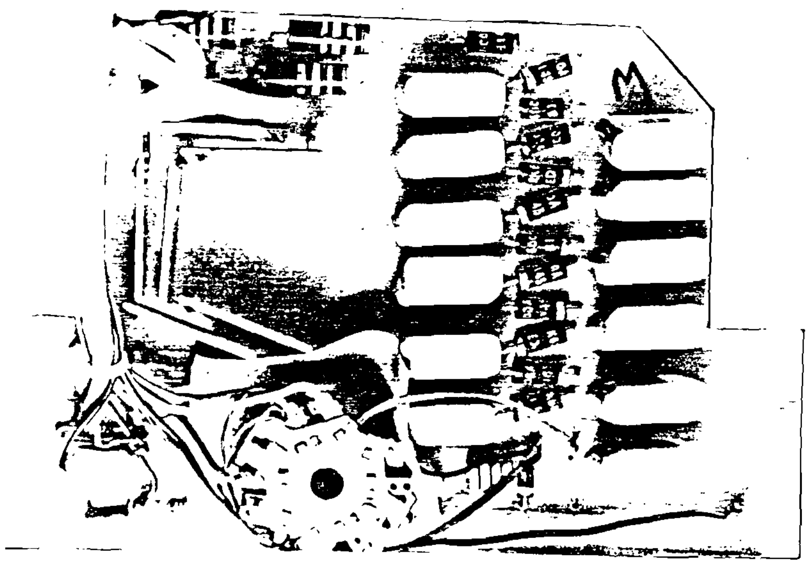


Figure A-4b. Front View of X12 Multiplier Circuit Card.(M)

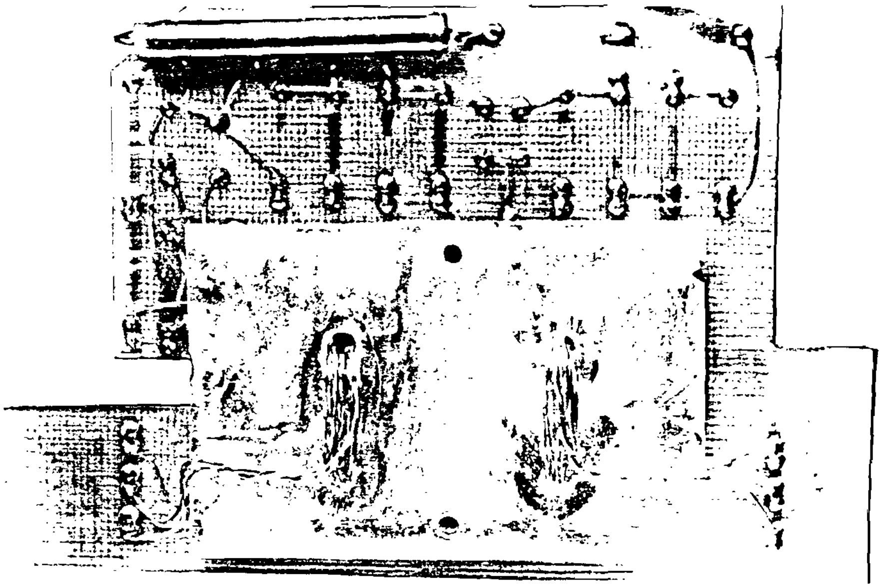


Figure A-5a. Rear View of Bias/Focus Multiplier Circuit Card.(F)

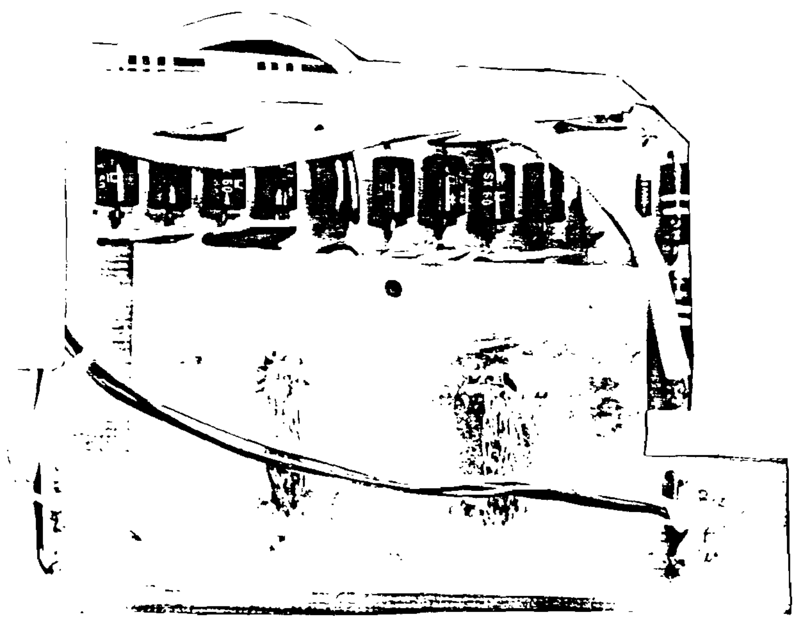


Figure A-5b. Front View of Bias/Focus Multiplier Circuit Card.(F)

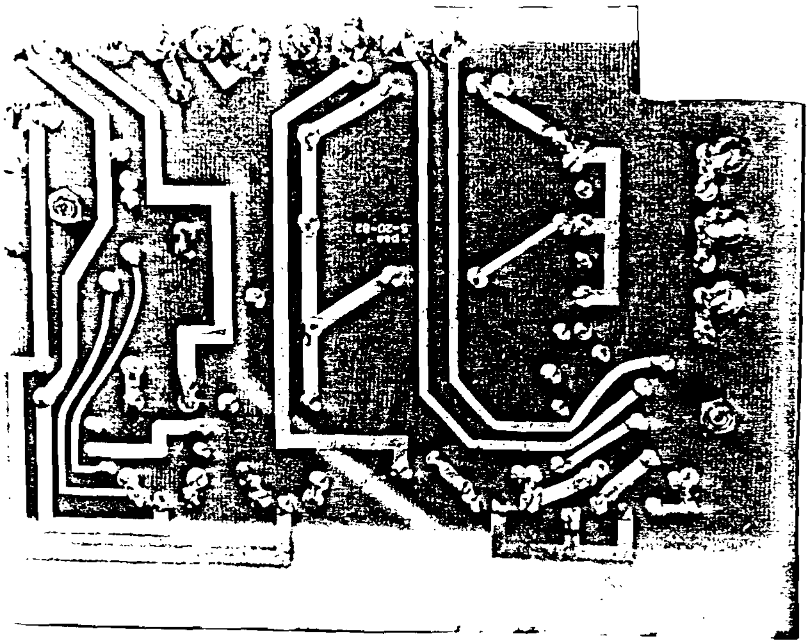


Figure A-6a. Rear View of Power Board Circuit Card.(P)

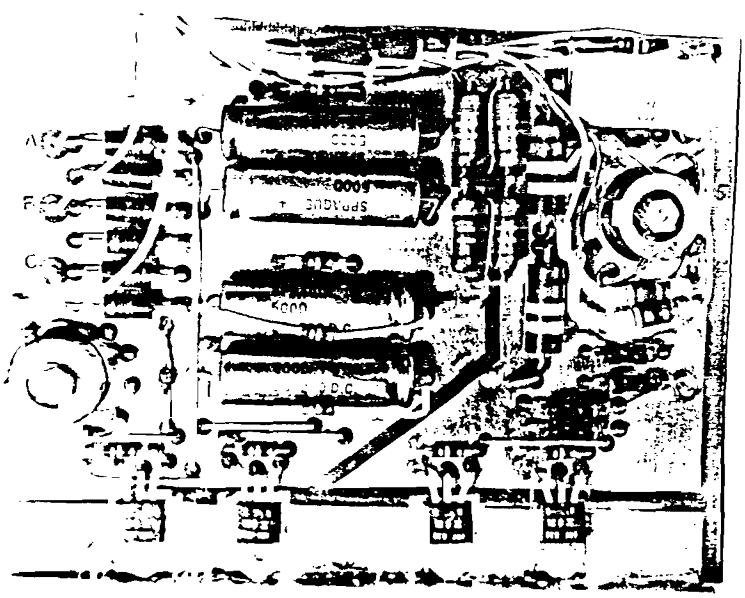


Figure A-6b. Front View of Power Board Circuit Card.(P)

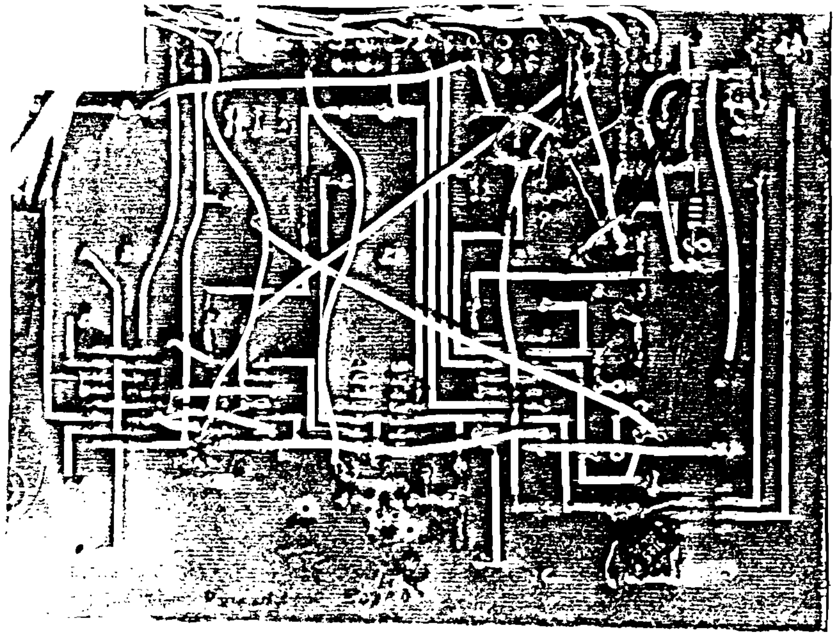


Figure A-7a. Rear View of -22KV Regulator Circuit Card.(R)

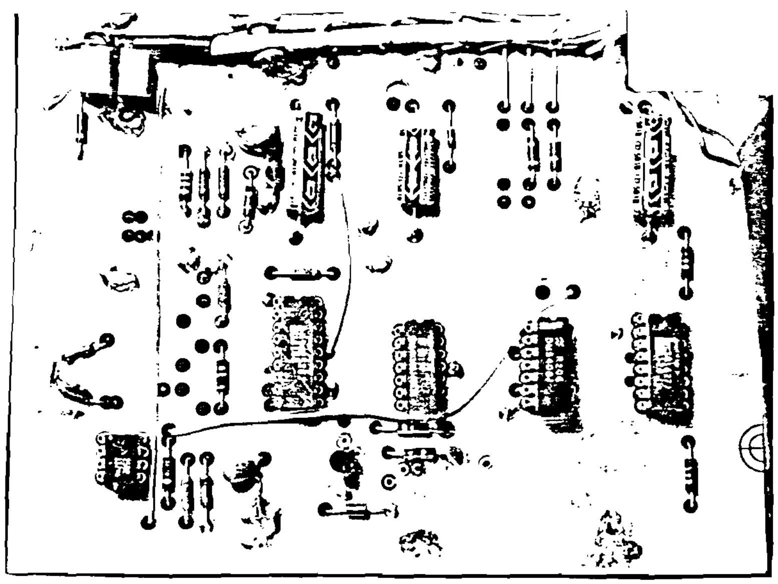


Figure A-7b. Front View of -22KV Regulator Circuit Card.(R)

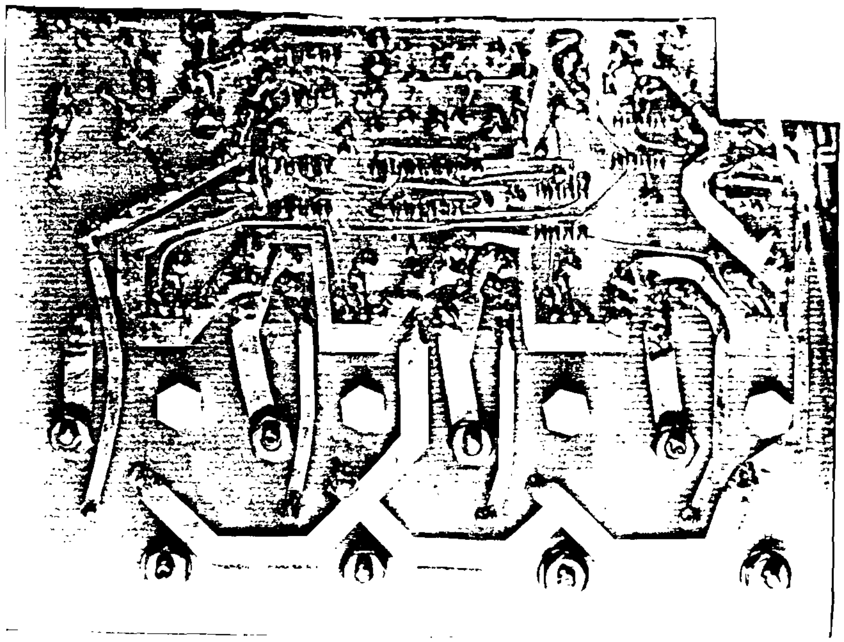


Figure A-8a. Rear View of Regulator/Chopper Circuit Card.(K)

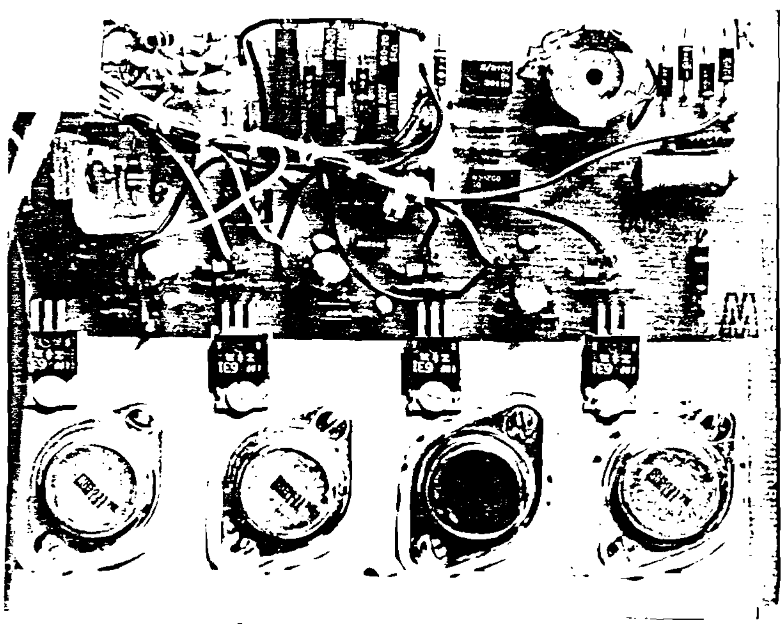


Figure A-8b. Front View of Regulator/Chopper Circuit Card.(K)

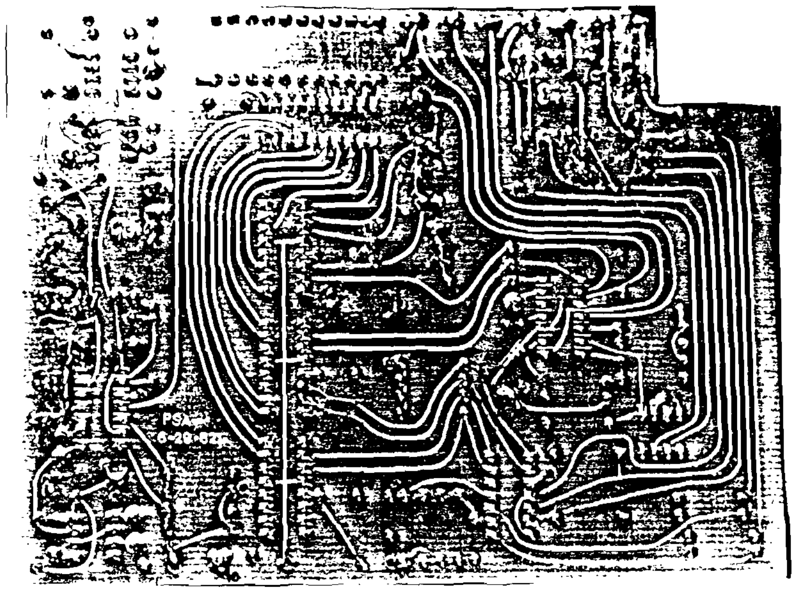


Figure A-9a. Rear View of Fault Protection Circuit Card.(T)

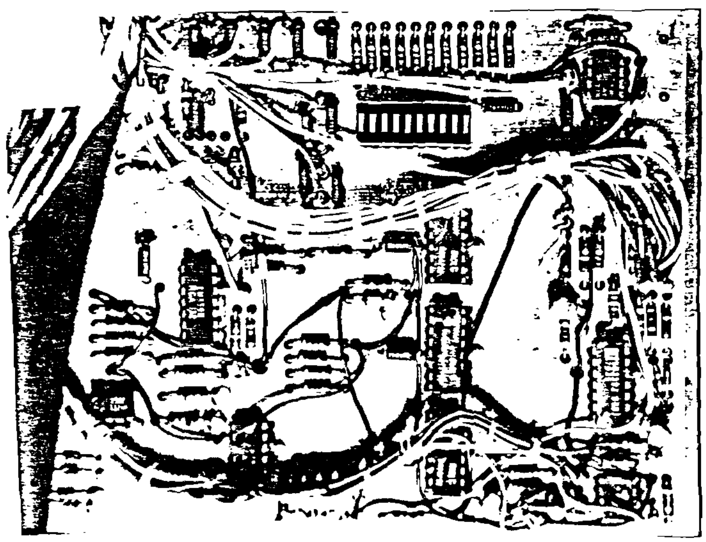


Figure A-9b. Front View of Fault Protection Circuit Card.(T)

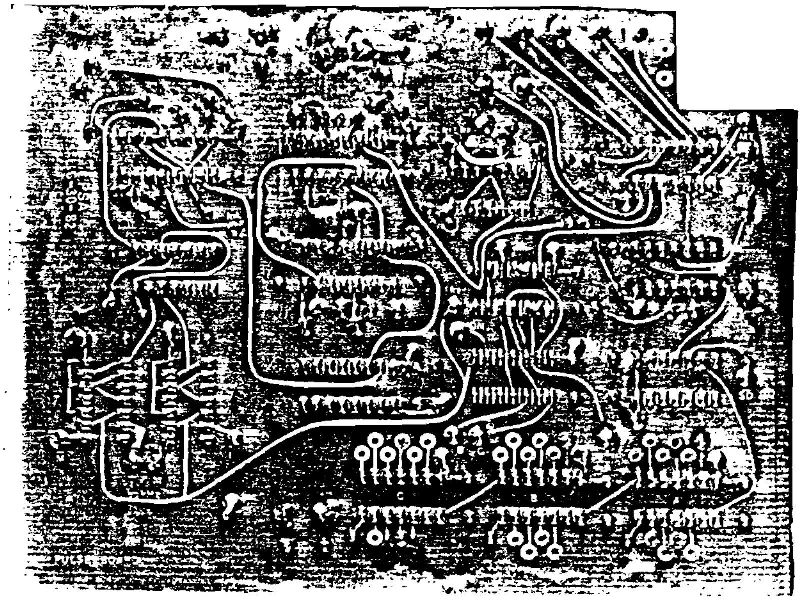


Figure A-10a. Rear View of Pulse Conditioning/Driver Circuit Card.(D)

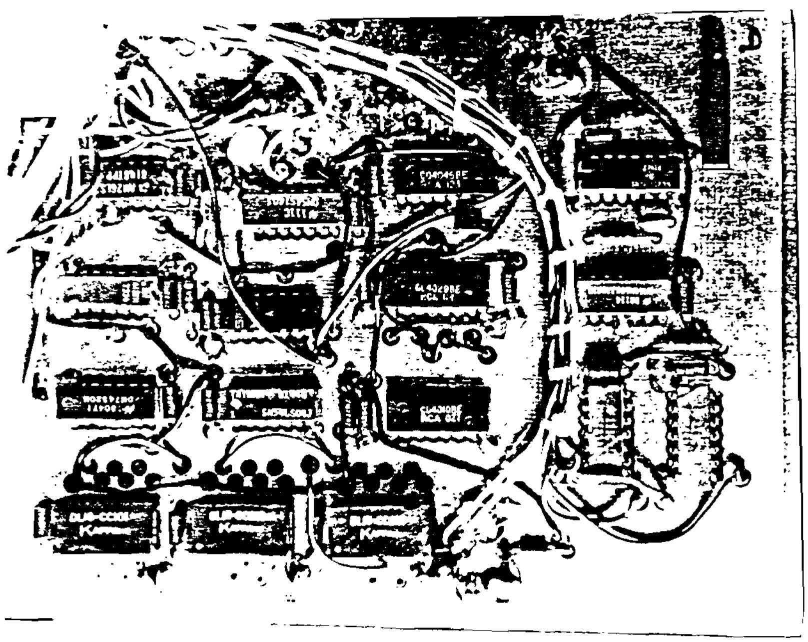


Figure A-10b. Front View of Pulse Conditioning/Driver Circuit Card.(D)

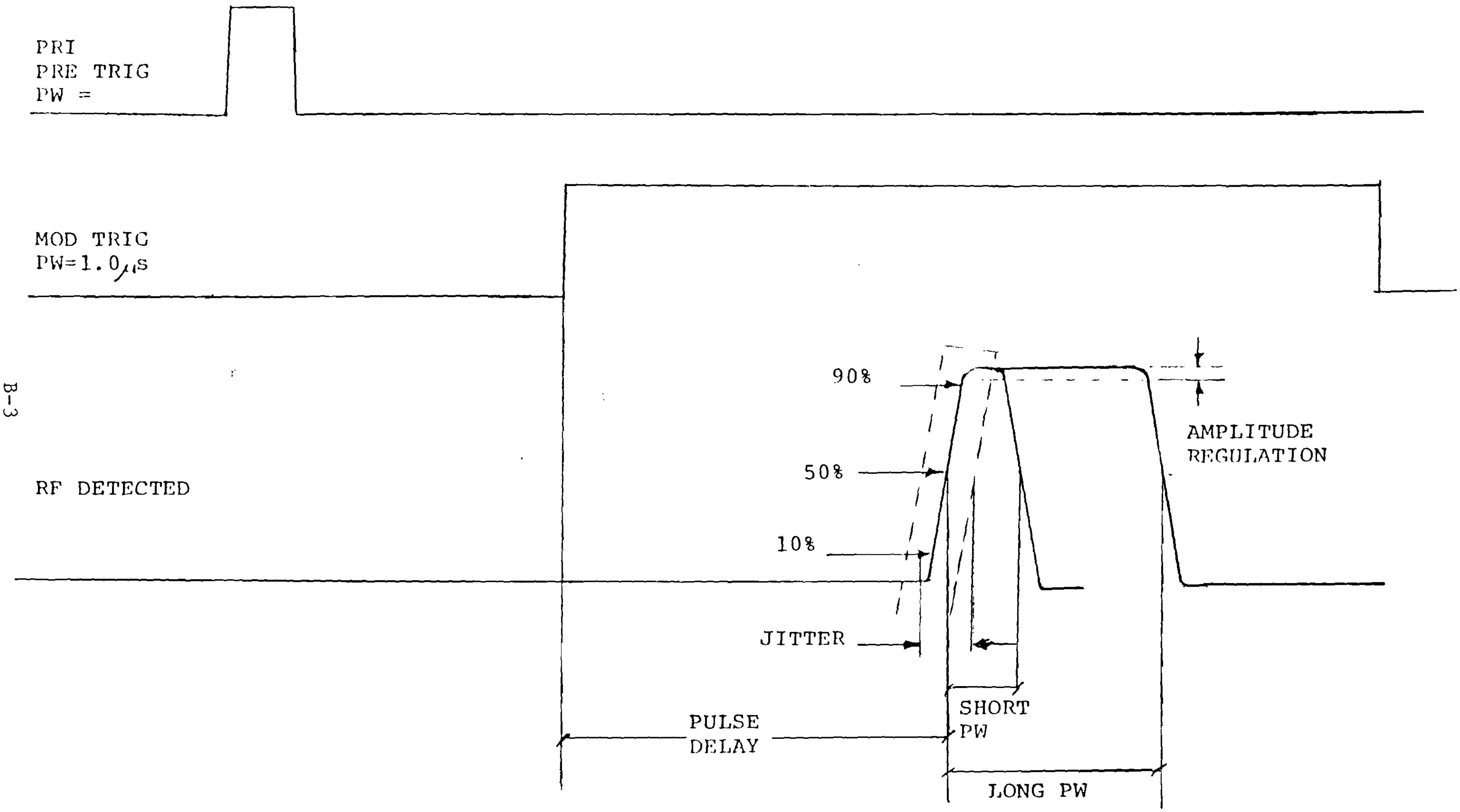
APPENDIX B

TALONS TRANSMITTER TEST PLAN

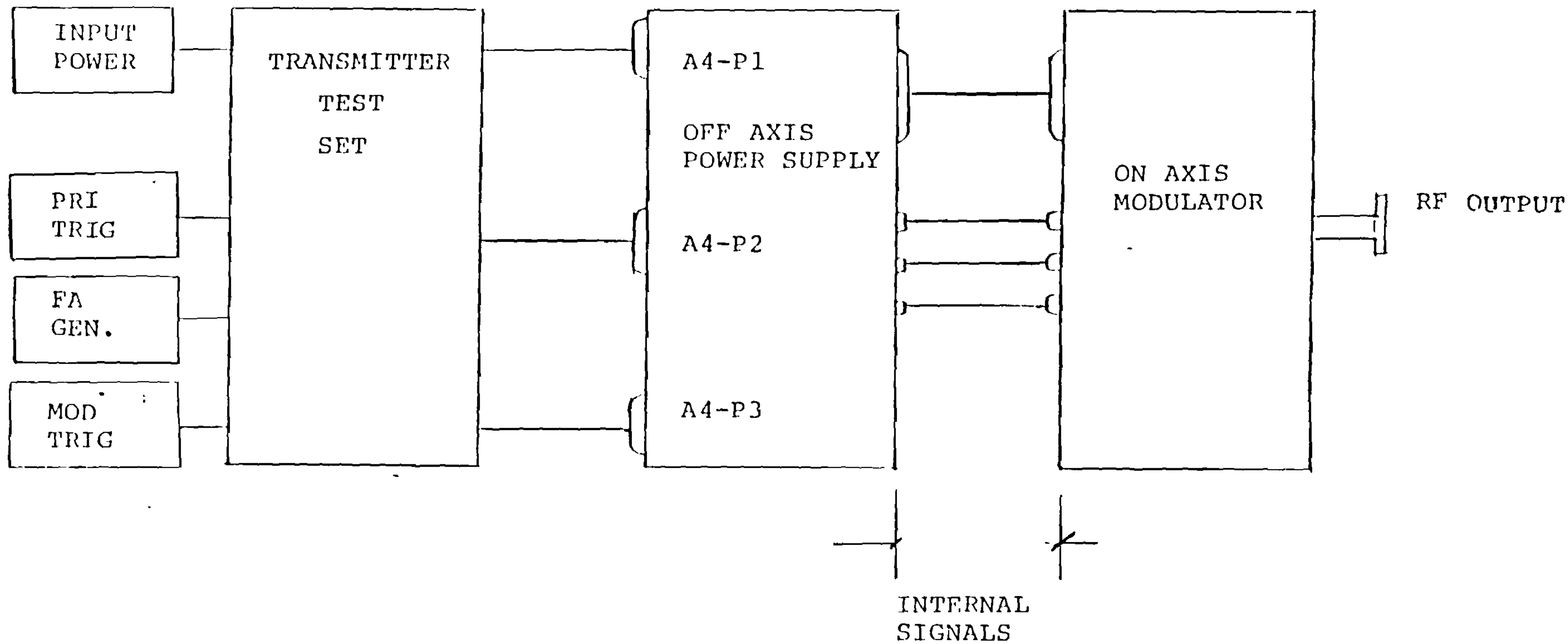
# TALONS TRANSMITTER
# TEST PLAN

## 1.0 INTRODUCTION

The TALONS transmitter shall be in accordance with NORDEN Specification 1339-S-0016. The Interface Signal Descriptions and Harness Drawings are given in Norden documents 1339-S-0028 and 1339-00440, respectively. A block diagram of the transmitter and associated test equipment configurations is given in Figure 1. The planned test data is listed in Table I. The definition of the data item listed and its measurement equipment configuration are given in the appropriate columns of this table. The measured test data shall be recorded in a suitable format indicating the test item in Table I.




INPUT AND RF PULSE DEFINITION




A4-P1 INPUT POWER

A4-P2 FUNCTION CONTROL SIGNALS

A4-P3 FA AND PW CONTROL SIGNALS

Figure 1 TALONS TRANSMITTER TEST EQUIPMENT CONFIGURATION

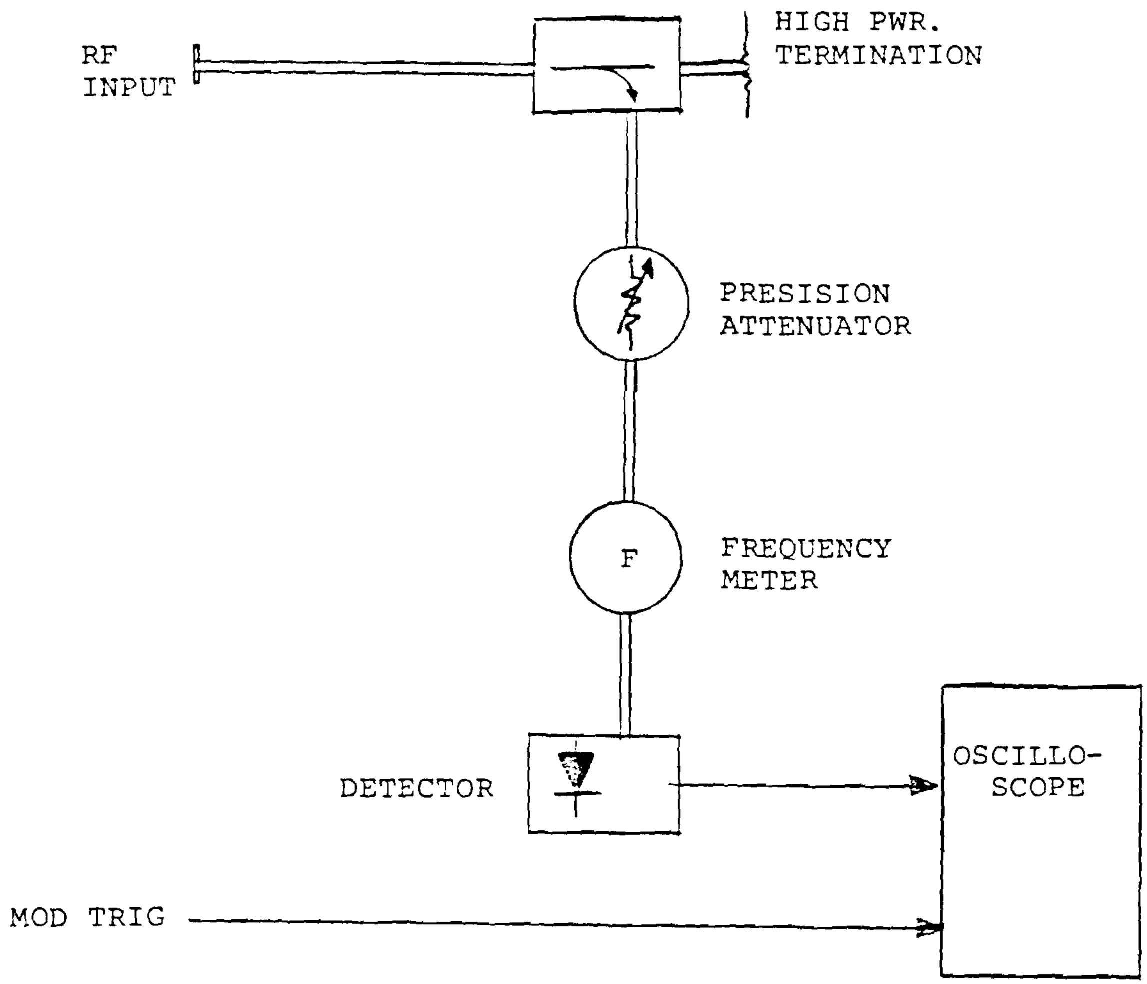



FIGURE 2 RF DETECTED PULSE TEST EQUIPMENT CONFIGURATION

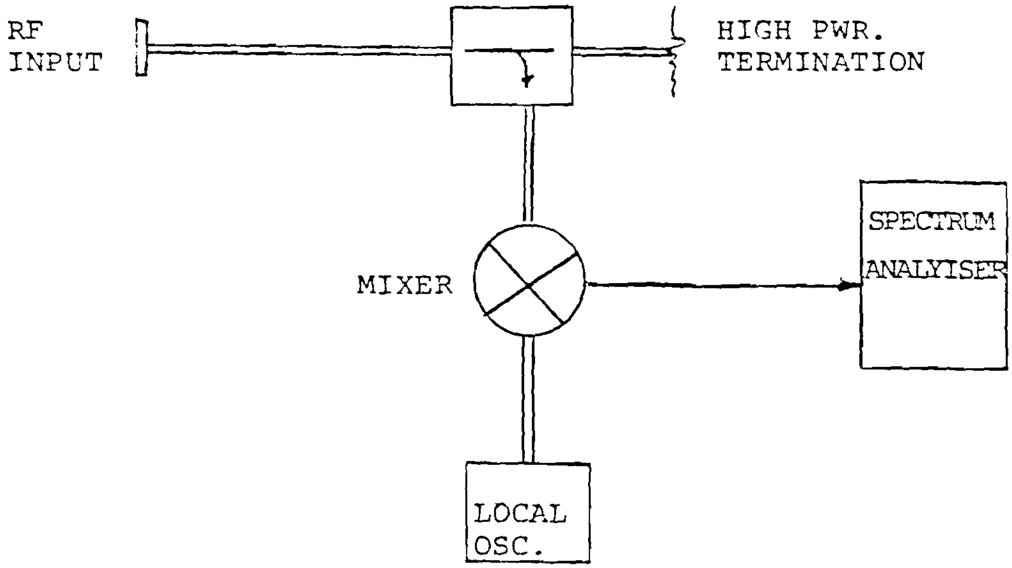



FIGURE 3   RF SPECRRUM TEST EQUIPMENT CONFIGURATION

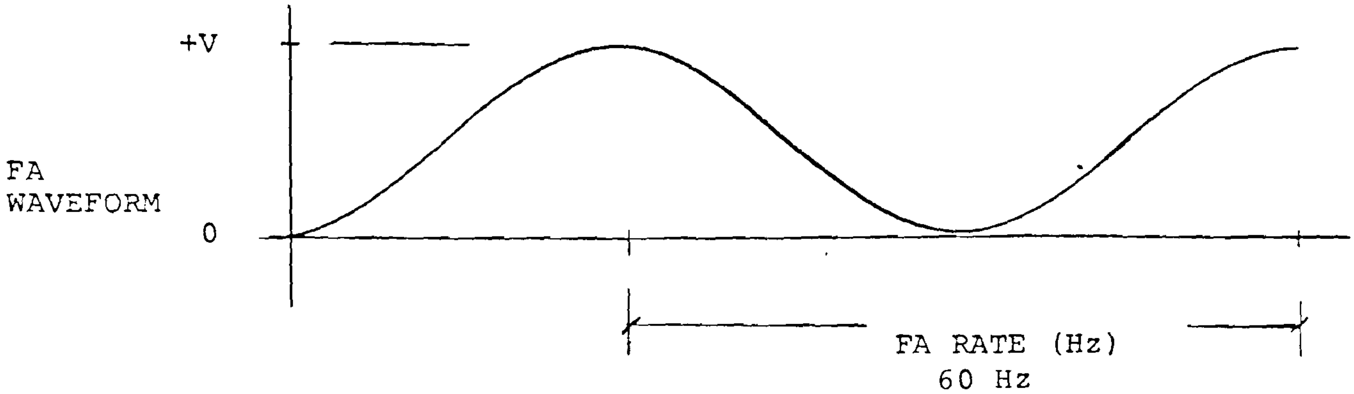
TABLE I- TALONS TRANSMITTER TEST DATA
(With EIO Serial Number)

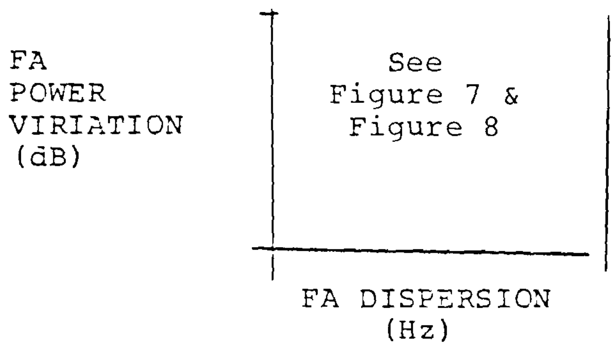
| TEST | TEST PARAMETERS | REFERENCE FIGURE | LONG PULSE | SHORT PULSE | UNITS | MEASURED VALUE |
|---|---|---|---|---|---|---|
| 1.1 | RF Pulse Width (50% pts.) | 2 | 400±40 | 80±8 | ns | FIGURE 2 |
| 1.2 | Rise, Fall Time (10-90% pts.) | 2 | 10.0 | 10.0 | ns | FIGURE 2 |
| 1.3 | Pulse Delay (MODTRIG to RF Pulse) | 2 | 100 | 100 | ns | FIGURE 2 |
| 1.4 | Pulse Jitter (Leading Edge) | 2 | 2.0 | 2.0 | ns, rms | FIGURE 2 |
| 1.5 | Amplitude Regulation (Pulse to Pulse) | 2 | ±1.0 | ±1.0 | % | FIGURE 2 |
| 1.6 | Frequency Variation (Pulse to Pulse) | - | 75.0 | 75.0 | KHz | FIGURE 2 |
| 1.7 | PRFVAR Limits | - | 6250-7500 | 6250-7500 | Hz | FIGURE 2 |
| 1.8 | Duty Cycle | - | .0025 - .003 | .0005 - .006 | - | -- |
| 1.9 | Long Term Stability (Exclusive of EIO) | - | 1.0 | 1.0 | MHz | Record Data at 30 sec. intervals for 6 mins. |
| 1.10 | Spectrum | - | -10 | -10 | dB | FIGURE 3 |
| 1.11 | Ave Power | - | - | - | W | EIO DATA SHEET |
| 1.12 | Peak Power (Ave Power x Duty) | - | - | - | KW | EIO DATA SHEET |
| 1.13 | FA Rate | 4 | 60 | 60 | Hz | FIGURE 4 |
| 1.14 | FA Dispersion | 4 | 100.0 | 100.0 | MHz | FIGURE 4 |
| 1.15 | FA Power Variation | 4 | 3.0 | 3.0 | dB | FIGURE 4 |

TALONS TRANSMITTER TEST DATA

Tests conducted with EIO VKB2445T1, S/N E0305K1.

| TEST | MEASURED VALUE Short , Long | UNITS | COMMENTS |
|---|---|---|---|
| 1.1 | 95 , 404 | nanoseconds | |
| 1.2 | 4 , 5 | nanoseconds | |
| 1.3 | 220 | nanoseconds | |
| 1.4 | 1 , 1 | nanoseconds | |
| 1.5 | Non-Detectable | % | With DC Supply |
| 1.6 | See Figure B-6 | | |
| 1.7 | 5.88 - 9 | kHz | |
| 1.8 | $7.1 \times 10^{-4}$ , $3.03 \times 10^{-3}$ | --- | PRF = 7.5 kHz |
| 1.9 | Non-Detectable Change | MHz | |
| 1.10 | See Figure B-6 | | |
| 1.11 | 3.02 | watts | |
| 1.12 | 1049 | watts | |
| 1.13 | 60 | Hz | |
| 1.14 | See Figures B-7, B-8 | | |
| 1.15 | See Figures B-7, B-8 | | |




| FA VOLTAGE (VAC) | OFFSET (VDC) | FA POWER | FA FREQ. | MECHANICAL SETTING | GHz | Pulse |
|---|---|---|---|---|---|---|
| 0.4 | 0 | See Figure 7a | 40 MHz | | 95 | Long |
| 1.0 | 0.2 | See Figure 8a | 100 MHz | | 95 | Long |
| 0.4 | 0 | See Figure 7b | 40 MHz | | 95 | Short |
| 1.0 | 0.2 | See Figure 8b | 100 MHz | | 95 | Short |

FIGURE 4 FA WAVEFORM DEFINITION

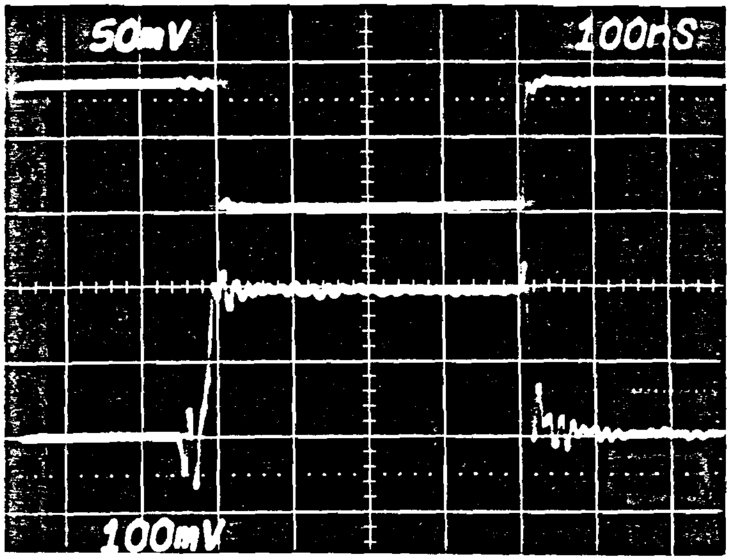



Figure B-5a. Photograph of Long Pulse
Top - RF Output
Bottom - Collector Current

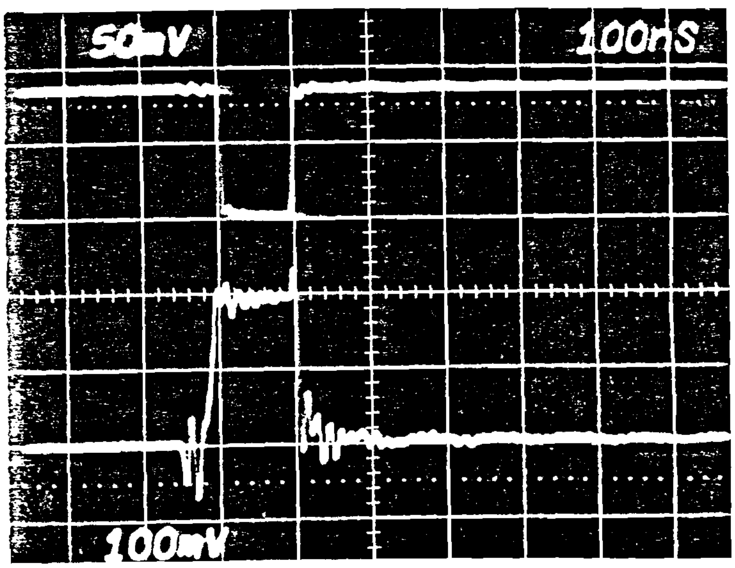



Figure B-5b. Photograph of Short Pulse
Top - RF Output
Bottom - Collector Current

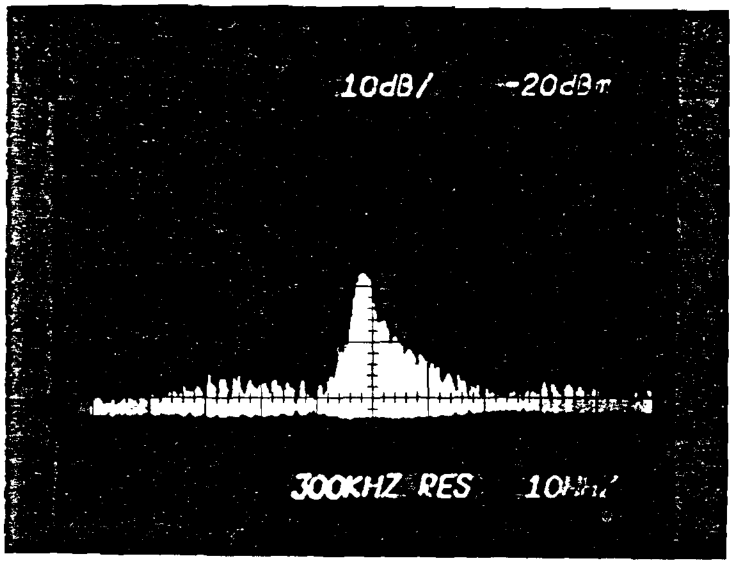



Figure B-6a. Frequency Spectrum of Long Pulse.

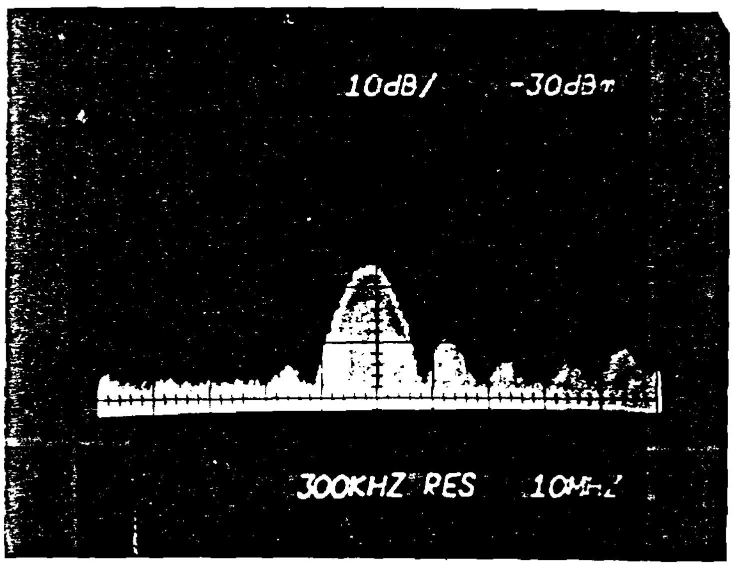



Figure B-6b. Frequency Spectrum of Short Pulse.

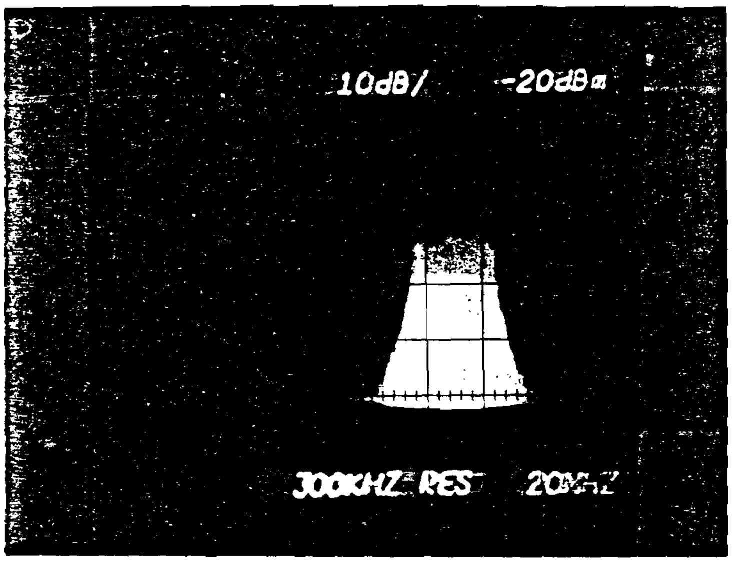



Figure B-7a. Spectrum of Long Pulse with Frequency Agility (FA Rate = 60 Hz, FA Dispersion = 40 MHz)

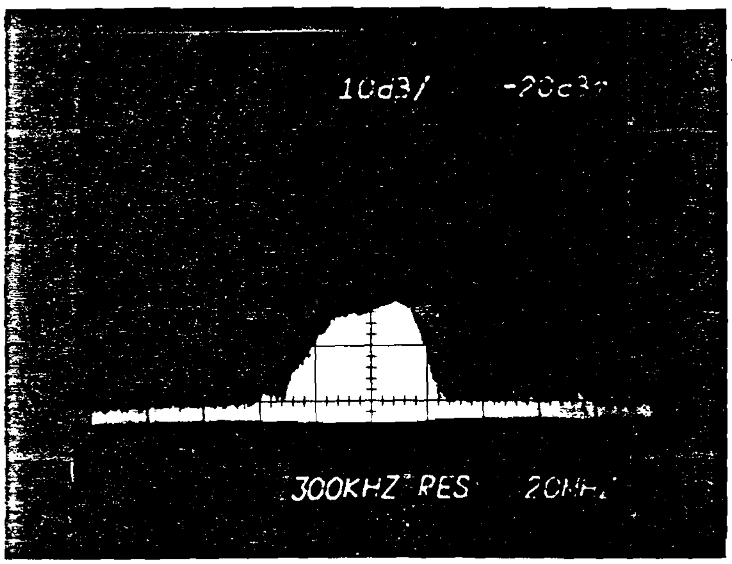



Figure B-7b. Spectrum of Short Pulse with Frequency Agility (FA Rate = 60 Hz, FA Dispersion = 40 MHz)

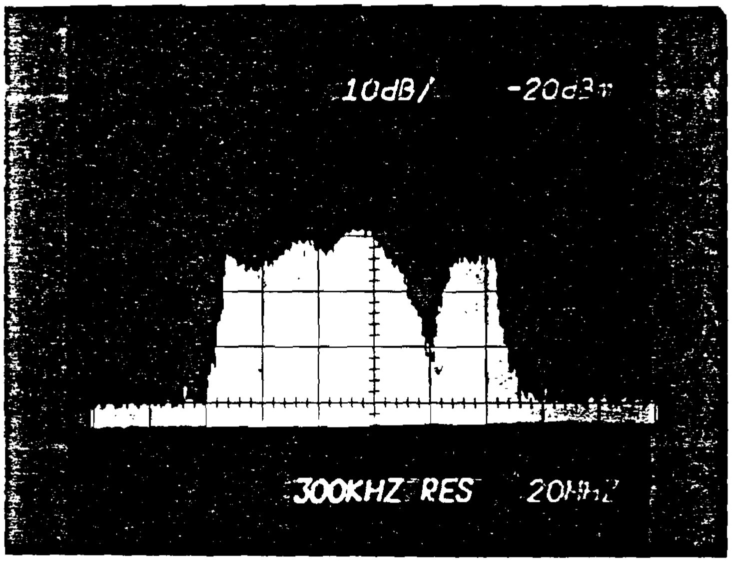



Figure B-8a. Spectrum of Long Pulse with Frequency Agility
(FA Rate = 60 Hz, FA Dispersion = 100 MHz)

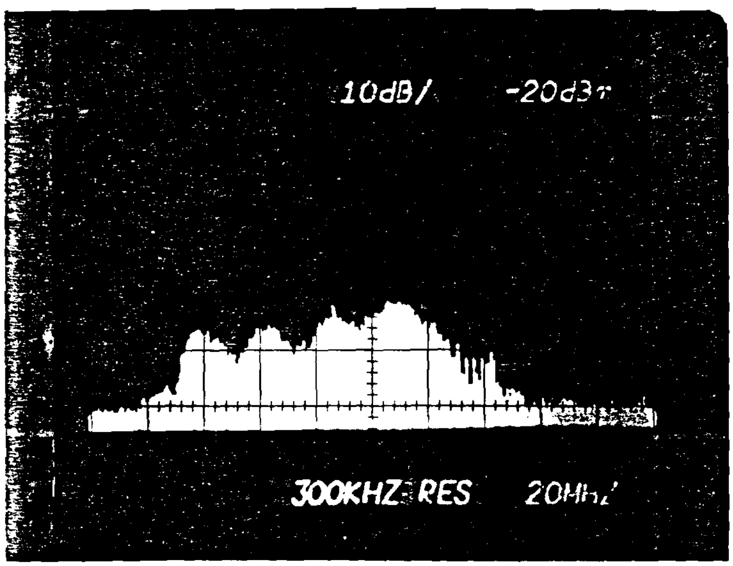
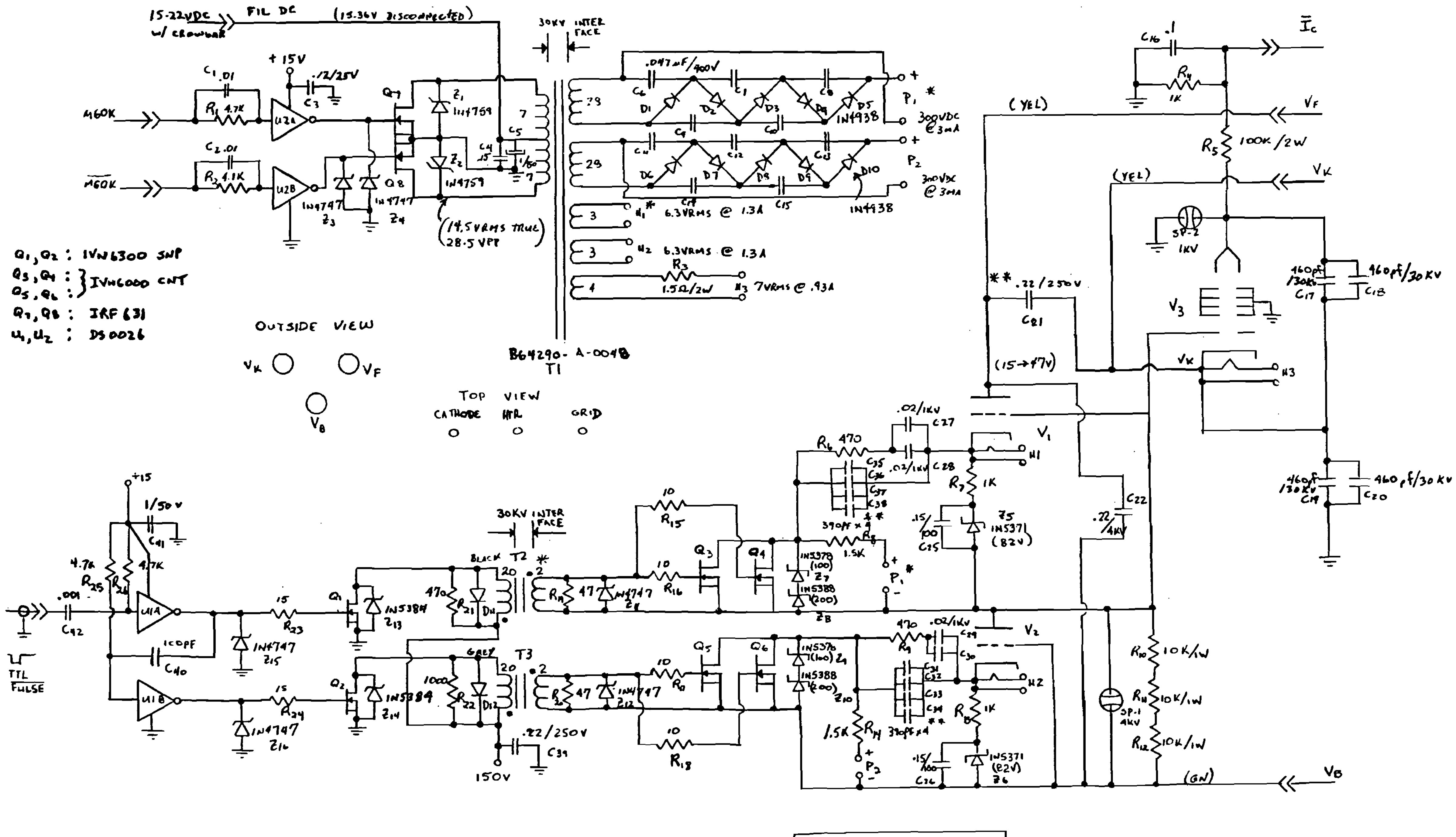



Figure B-8b. Spectrum of Short Pulse with Frequency Agility
(FA Rate = 60 Hz, FA Dispersion = 100 MHz)

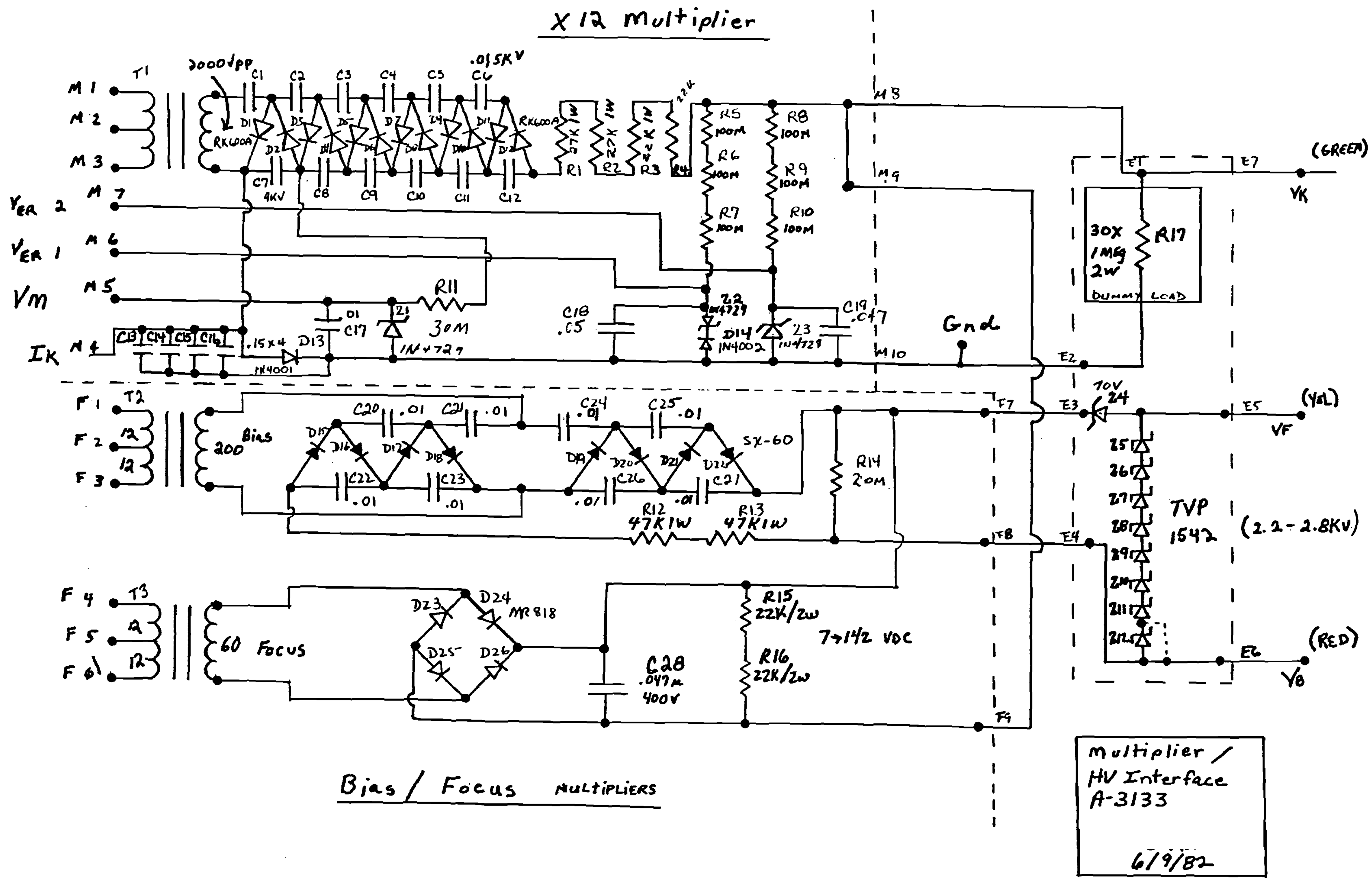
# APPENDIX C

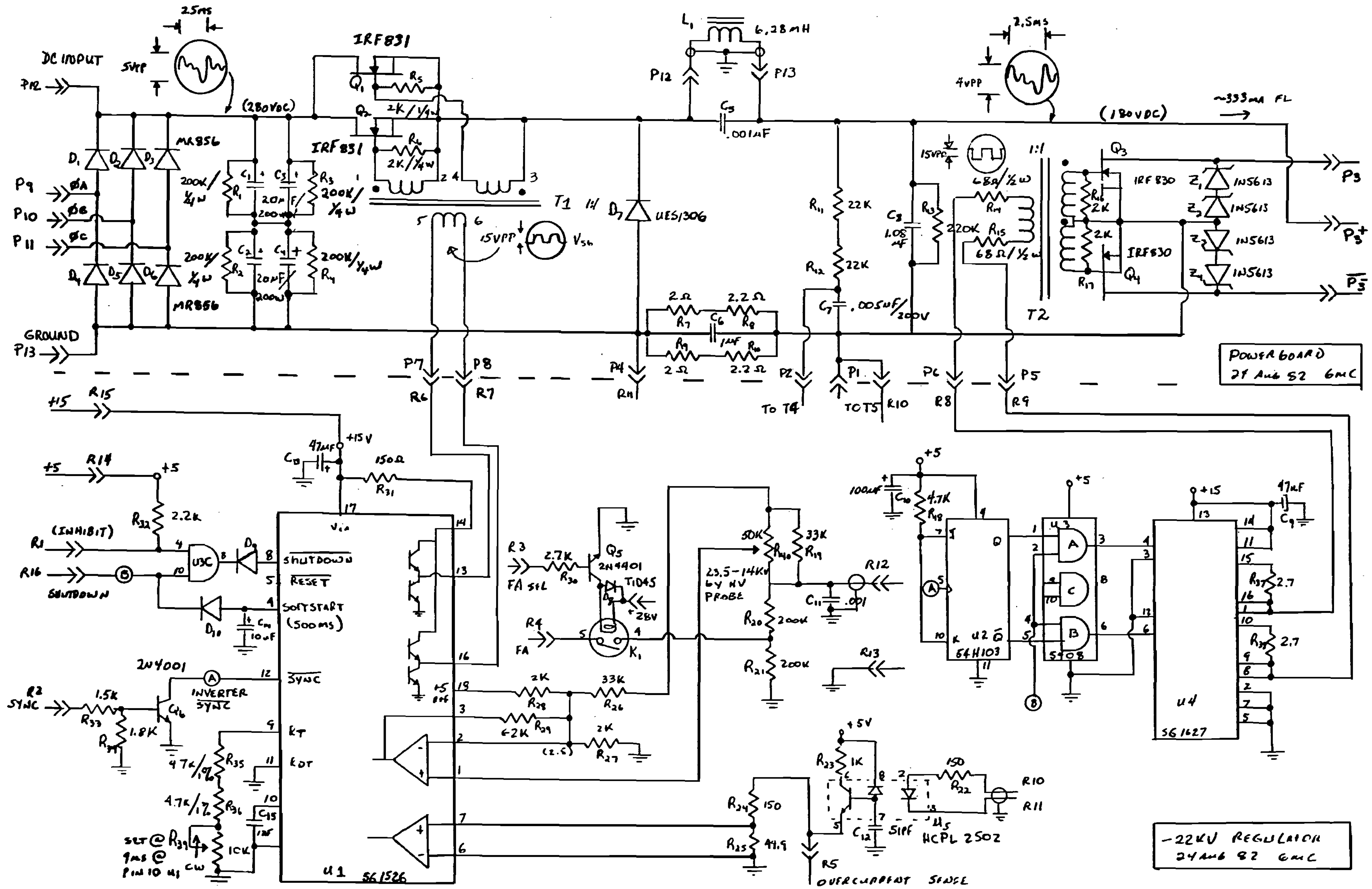
# SCHEMATIC DIAGRAMS



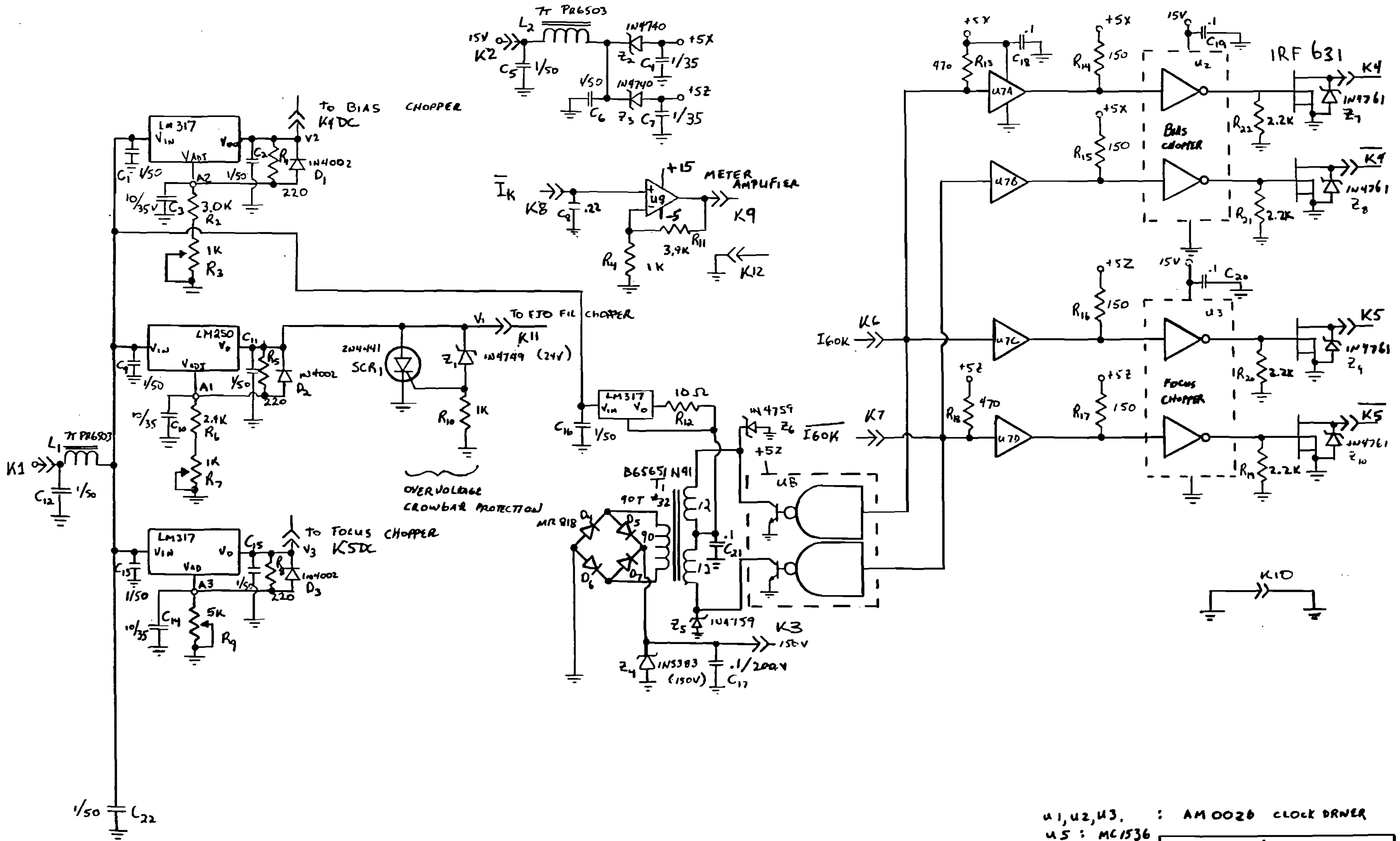

| NORDEN MODULATOR | |
|---|---|
| A 3133 | GMC |
| MOD 1 | 11 JULY 82 |

* LOW CAPACITY
** LOW INDUCTANCE


X 12 Multiplier
Bias / Focus multipliers
Multiplier / HV Interface A-3133
6/9/82
M 1
M 2
M 3
T1
2000VPP
.015KV
RK600A
$V_{ER}$ 2
M 7
$V_{ER}$ 1
M 6
Vm
M 5
Ik
M 4
R11
30M
1N4729
D13
1N4001
C17
.01
C18
.05
D14
1N4002
C19
.047
Z2
1N4729
Z3
1N4729
R5 100M
R6 100M
R7 100M
R8 100M
R9 100M
R10 100M
M 8
M 9
M 10
Gnd
E1
E7
(GREEN)
VK
30X
1MEG
2W
R17
DUMMY LOAD
E2
E3
70V
Z4
E5
(YEL)
VF
TVP
1542
(2.2 - 2.8KV)
E4
E6
(RED)
VB
F 1
F 2
F 3
T2
200 Bias
SX-60
R14
20M
R12
47K 1W
R13
47K 1W
F7
F8
F 4
F 5
F 6
T3
60 Focus
D23
D24
MR818
D25
D26
C28
.047μ
400V
R15
22K/2W
R16
22K/2W
7→142 VDC
F9

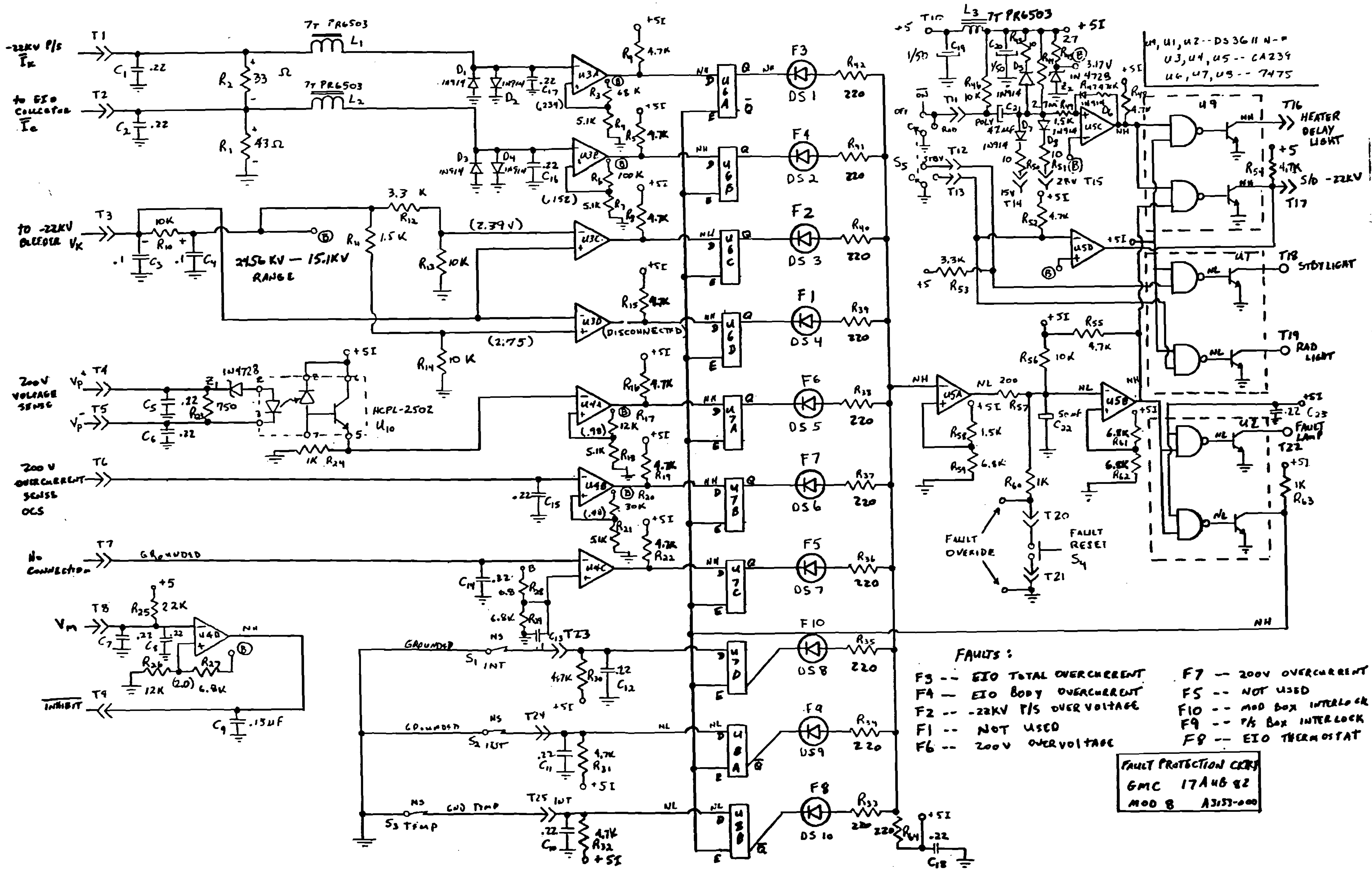


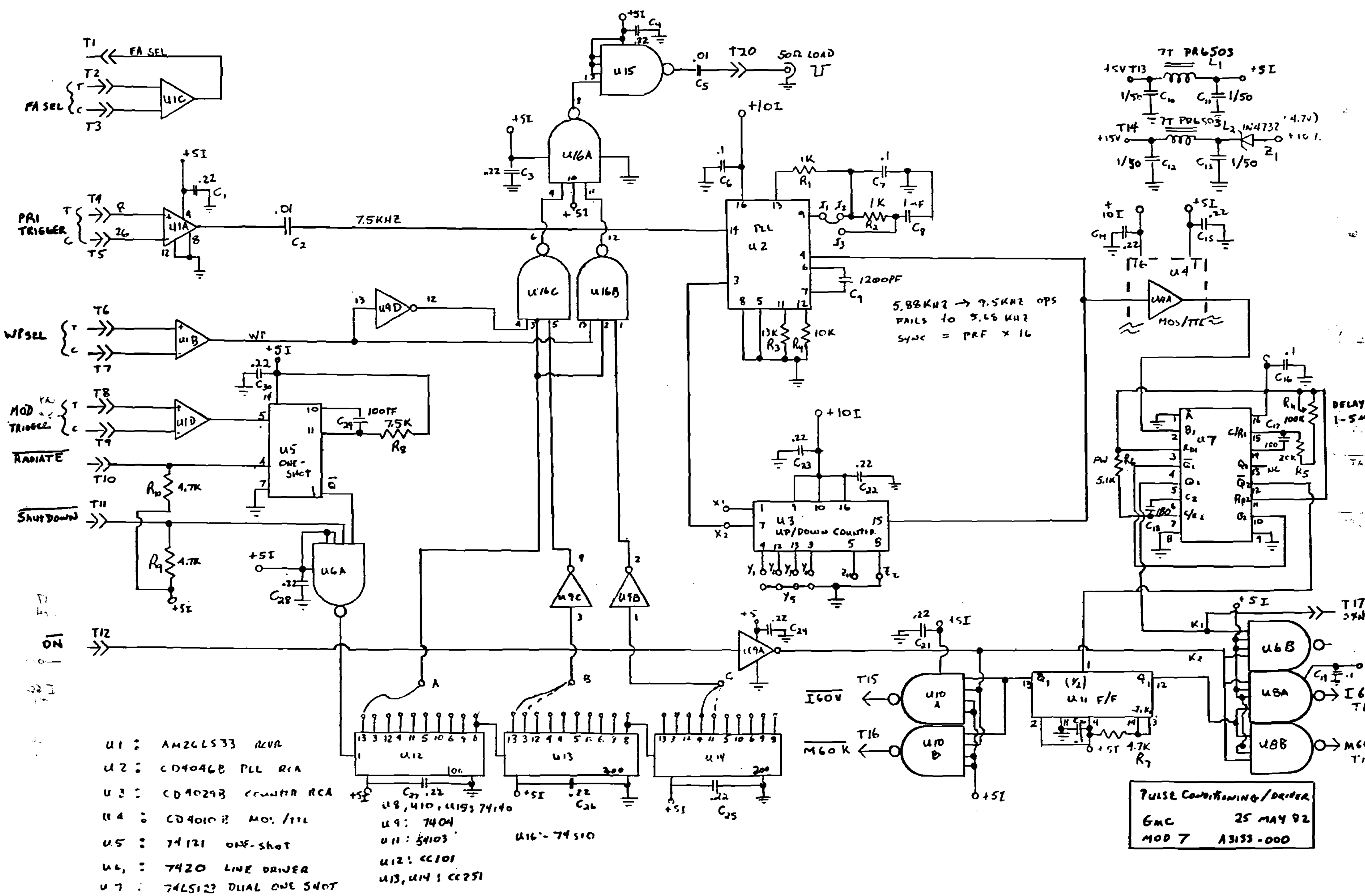
DC INPUT
GROUND
IRF831
MR856
T1 1:1
UES1306
L1 6.28 mH
(280VDC)
(180VDC)
~333mA FL
T2
IRF830
1N5613
SG1526
SG1627
54H103
5408
HCPL 2502
2N4401
TID45
OVERCURRENT SENSE
POWER BOARD 24 Aug 82 GMC
-22KV REGULATOR 24 Aug 82 GMC



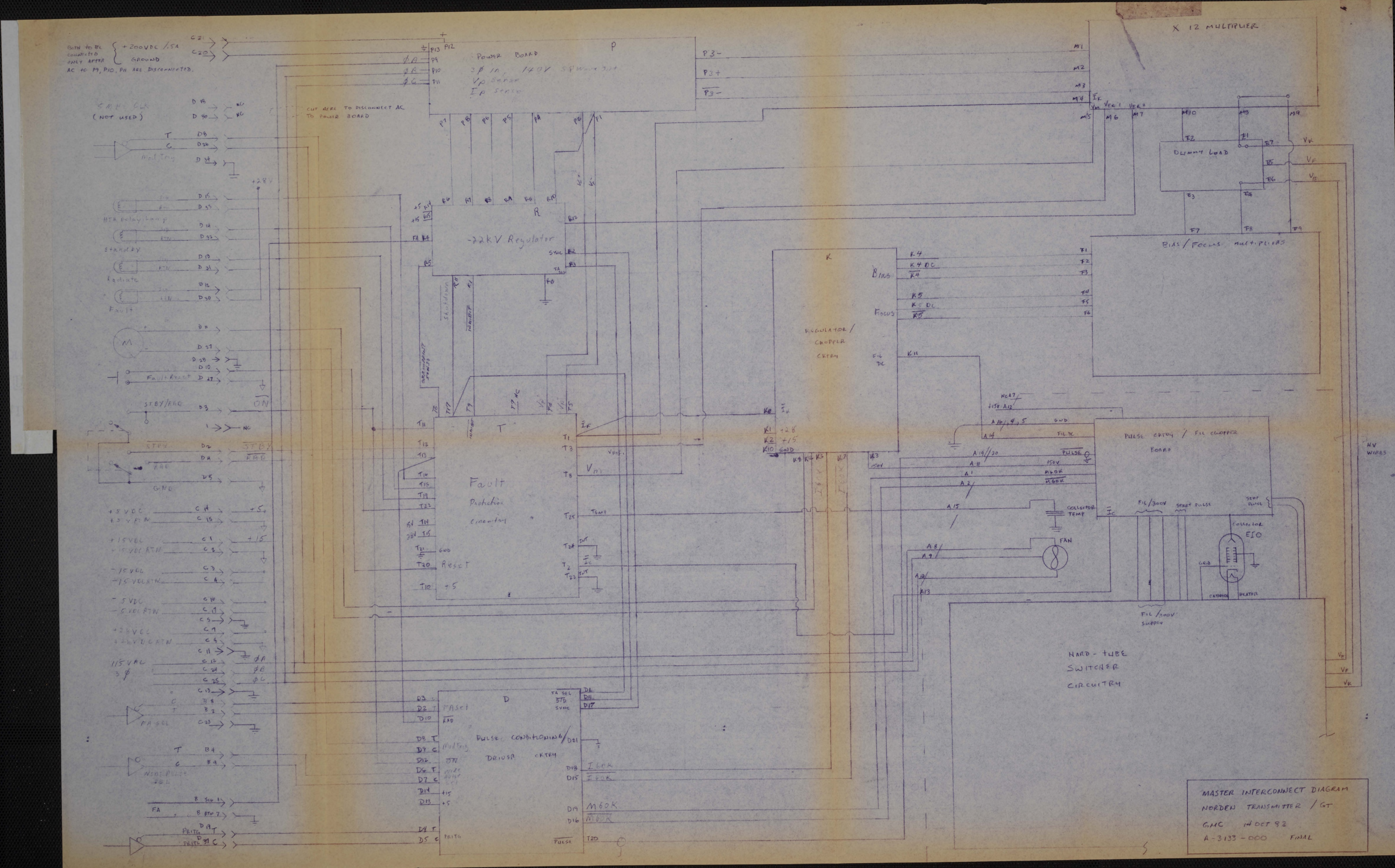

u1, u2, u3. : AM0026 CLOCK DRIVER
u5 : MC1536
u6, u7: 7407
u8 : DS3611 N
u9 : MC1536

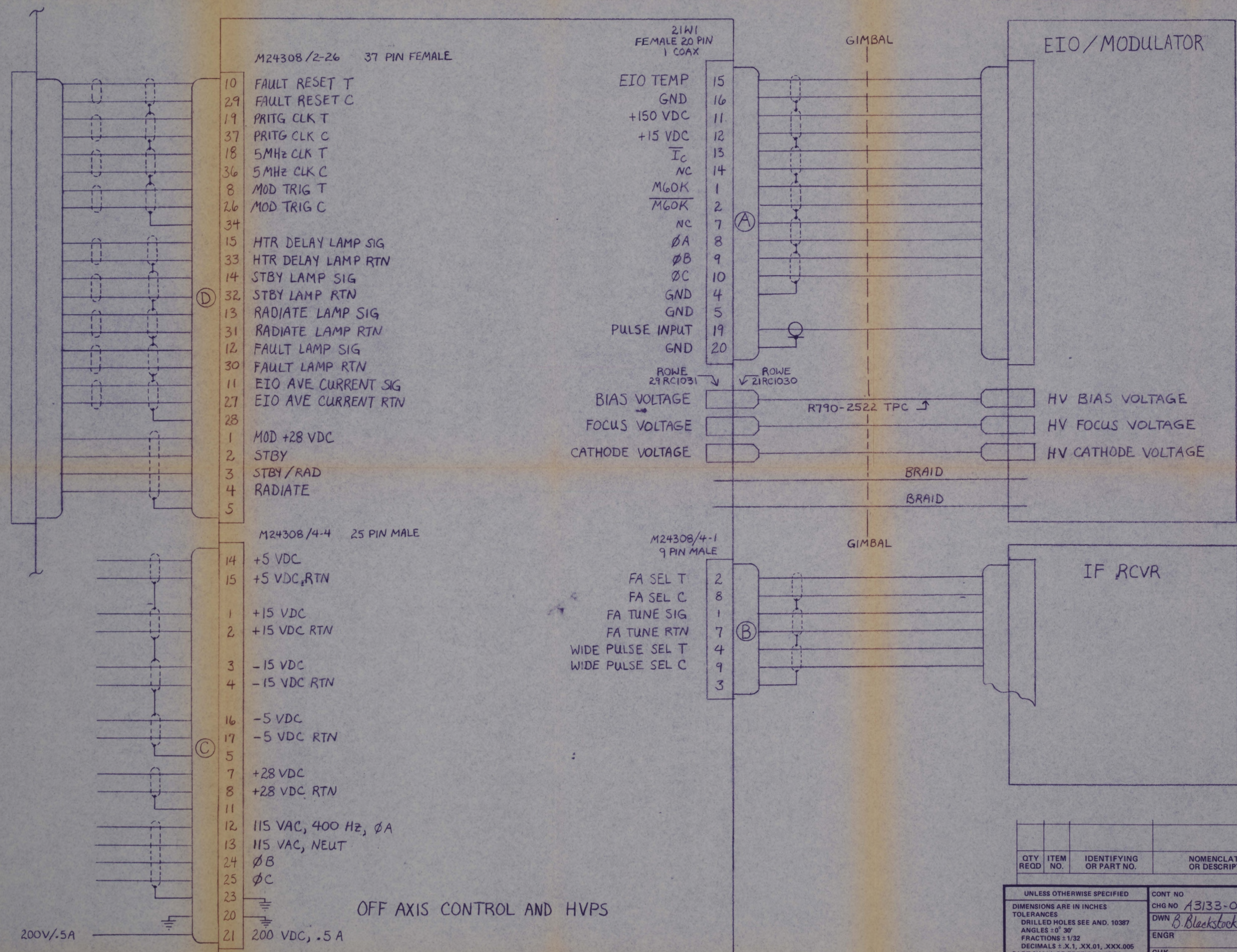
| REGULATOR / CHOPPER CKTRY | |
|---|---|
| GMC | 1 JUNE 82 |
| MOD 2 | A 3133 |


FAULTS:
F3 -- EIO TOTAL OVERCURRENT
F4 -- EIO BODY OVERCURRENT
F2 -- -22KV P/S OVER VOLTAGE
F1 -- NOT USED
F6 -- 200V OVERVOLTAGE
F7 -- 200V OVERCURRENT
F5 -- NOT USED
F10 -- MOD BOX INTERLOCK
F9 -- P/S BOX INTERLOCK
F8 -- EIO THERMOSTAT
U1, U2 -- DS3611N-P
U3, U4, U5 -- CA239
U6, U7, U8 -- 7475
FAULT PROTECTION CKT
GMC 17 AUG 82
MOD 8 A3153-000



FA SEL
PRI TRIGGER
WP SEL
MOD TRIGGER
RADIATE
SHUTDOWN
ON
7.5KHZ
50Ω LOAD
5.88KHZ → 9.5KHZ OPS
FAILS to 5.65 KHZ
SYNC = PRF × 16
UP/DOWN COUNTER
MOS/TTL
DELAY 1-5MS
7T PR6503
IN4732
I60K
M60K
SYNC
U1: AM26LS33 RCVR
U2: CD4046B PLL RCA
U3: CD4029B COUNTER RCA
U4: CD4010 MOS/TTL
U5: 74121 ONE-SHOT
U6: 7420 LINE DRIVER
U7: 74LS123 DUAL ONE SHOT
U8, U10, U15: 74140
U9: 7404
U11: 54103
U12: CC101
U13, U14: CC251
U16: 74S10
PULSE CONDITIONING/DRIVER
GMC 25 MAY 82
MOD 7 A3153-000


X 12 MULTIPLIER
POWER BOARD
-22kV Regulator
DUMMY LOAD
BIAS / FOCUS MULTIPLIERS
REGULATOR / CHOPPER CKTRY
Fault Protection Circuitry
PULSE CKTRY / FIL CHOPPER BOARD
FAN
HARD-TUBE SWITCHER CIRCUITRY
PULSE CONDITIONING / DRIVER CKTRY
CUT HERE TO DISCONNECT AC TO POWER BOARD
HV WIRES
MASTER INTERCONNECT DIAGRAM
NORDEN TRANSMITTER / GT
GMC 14 OCT 82
A-3133-000 FINAL




| APPLICATION | | | |
|---|---|---|---|
| ITEM | QTY REQD | NEXT ASSY | USED ON |

| REVISIONS | | | | |
|---|---|---|---|---|
| ZONE | REV | DESCRIPTION | DATE | APPROVED |

| QTY REQD | ITEM NO. | IDENTIFYING OR PART NO. | NOMENCLATURE OR DESCRIPTION | MATERIAL | STOCK SIZE | MATL SPEC | FSCM NO. |
|---|---|---|---|---|---|---|---|

PARTS LIST

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES
DRILLED HOLES SEE AND. 10387
ANGLES ±0° 30'
FRACTIONS ±1/32
DECIMALS ±.X.1, .XX.01, .XXX.005
PART SHALL BE FREE OF BURRS
BROKEN EDGES .015 MAX.
FILLETS .015 R MAX.
SURFACE ROUGHNESS 125
DO NOT SCALE THIS DRAWING
INTERPRET DRAWING

CONT NO
CHG NO A3133-000
DWN B. Blackstock 10-13-82
ENGR
CHK
PROD
APVD

ENGINEERING EXPERIMENT STATION
OF THE
GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA

TALONS: HVPS/MODULATOR HARNESS LAYOUT

FSCM NO. 07101 | SIZE D | DRAWING NO.